

JPRS-UMA-94-007  
16 February 1994



---

# ***JPRS Report***

## **Central Eurasia**

---

***Military Affairs***  
***Bulletins of Foreign S&T Information***

# Central Eurasia

## Military Affairs

### Bulletins of Foreign S&T Information

JPRS-UMA-94-007

## CONTENTS

16 February 1994

94A50006 Moscow BYULLETen INOSTRANNOY NAUCHNOY I TEKNICHESKOY INFORMATSII in Russian  
Nos 39, 41, 42; 1992 pp 1-55, 1-63, 1-55

[This special issue of the Military Affairs book is a translation of BYULLETen INOSTRANNOY I TEKNICHESKOY INFORMATSII (Bulletins of Foreign Science and Technology Information) Nos 39, 41 and 42.]

[The following disclaimer appears in the original table of contents as a boxed passage: Science and technology news is obtained through foreign newspapers, magazines, and information agency reports without assessment of the reliability of individual sources.]

### AVIATION AND COSMONAUTICS

#### "Mosaeroshow-92" Russian Aerospace Exhibition (Survey)

1. Military Aircraft .....	3
Aircraft of the OKB imeni A.N. Tupolev .....	3
Aircraft of the OKB imeni P.O. Sukhoy .....	6
Aircraft of the OKB imeni S.V. Ilyushin .....	13
Aircraft of the OKB imeni A.I. Mikoyan .....	14
ANTK imeni O.K. Antonov Aircraft .....	25
OKB imeni S.V. Ilyushin Aircraft .....	28
2. Helicopters .....	28
The Mi-24 Army Combat Transport Helicopter .....	28
The Ka-50 Fire Support Helicopter .....	29
The Mi-28 Fire Support Helicopter .....	30
OKB imeni M.L. Mil Future Aircraft .....	32
3. Trainer Aircraft .....	33
4. Aircraft of Special Designs .....	35
5. Remotely Piloted Vehicles .....	41

### PHYSICS

New Theory Explains Anomalous Properties of Water .....	42
Berlin Builds a Second Synchrotron .....	43

### CHEMISTRY

Boron Molecules that Look Like Fullerenes .....	43
---	----

### COMPUTER EQUIPMENT

IBM and Hewlett-Packard Innovations .....	43
Cray Receives Contract from NASA .....	44

### POWER ENGINEERING

Prospects for Solar Power Engineering in Japan .....	44
--	----

## NEW TECHNOLOGIES

Processing Explosives into Fertilizers .....	45
Tire Scrapping Technology .....	45
Electricity Extinguishes Fires .....	45

## INSTRUMENT BUILDING

Shortcomings of Atomic Microscope .....	46
VIPER Explosives Detector .....	46

## AUTOMOBILE MAKING

Mitsubishi's New 3000GT Automobile .....	46
Sale of Allison Transmission .....	47
Robot To Replace Oil in Automobile Engine .....	47

## NEW MATERIALS

Solid, Lighter Than Air Material .....	47
--	----

## ECONOMICS

Japan Proposes Scientific Research Effectiveness Criteria .....	48
Expenditures on Space Programs .....	48
Germany Increases Amount of Financing for Scientific Research .....	49
Siemens and Philips Joint Ventures in Germany and China .....	49
South Korea Finances Leading Technology Projects .....	49
R&D Expenditures in OECD Countries .....	50
Tax on Packaging .....	50

## VARIOUS

Wheelchair Permits Disabled Persons To Move While Standing .....	51
--	----

## "Mosaeroshow-92" Russian Aerospace Exhibition (Survey Continued)

6. Aircraft Armament .....	51
Air-to-Air Missiles .....	51
Air-to-Surface Guided Missiles and Antiship Missiles .....	53
Antisubmarine Warfare Weapons .....	58
Guided Aircraft Bombs .....	58
Unguided Aircraft Rockets .....	60
Aircraft Artillery Weapons .....	61
7. Ground-Based and Shipborne Missile and Artillery Systems .....	61
Antiaircraft Missile Weapons .....	61
Dual and Multipurpose Tactical Missile-Artillery Systems .....	66
Shipborne Antiaircraft Missiles .....	69
Multiple Rocket Launcher Systems .....	72
8. Electronics and Reconnaissance Equipment .....	73

## BULLETINS OF FOREIGN S&T INFORMATION

94A50006A Moscow BYULLETEN INOSTRANNOY NAUCHNOY I TEKHNICHESKOY INFORMATSII in Russian No 39, 41, 42, 1992, pp 1-55, 1-64, 1-55

[Bulletin of Foreign Scientific and Technical Information No 39 (2597), 29 September 1992; No 41 (2599), 13 October 1992; No 42 (2600), 20 October 1992, published by the Information and Operational Scientific-Technical Information Agency: "Bulletin of Foreign Scientific and Technical Information, Series 1: THE NATURAL SCIENCES AND TECHNOLOGY"]

[No 39, 29 September 1992, pp 1-55]

[Text]

## AVIATION AND COSMONAUTICS

### "Mosaeroshow-92" Russian Aerospace Exhibition (Survey)

The "Mosaeroshow-92" Russian International Aerospace Exhibition took place on 11-16 August 1992 in the Moscow suburb of Zhukovskiy. The Flying-Research Institute (LII) imeni M.M. Gromov, Aviaekspost Association, and the German firm Glahe International organized it. The exhibition received experts and journalists from 11 through 14 August and everyone who wished to attend on 15 and 16 August, and an air show was conducted on 16 August in honor of Air Force Day.

The exhibition took place at an airfield belonging to LII, the main VPP [runway] of which is 5,500 meters long. There are no such large airfields in Europe, and only the airfield at Edwards Air Base in the United States can be compared to it. Russia spent 85 million rubles [R] to

organize the air show, of which R60 million was spent on construction of roads and city infrastructure and R25 million on development of the exhibition complex itself. A portion of the expenditures was covered by the cost of entry tickets. With the price of a ticket at R30, the amount of proceeds from entry payments totaled more than R8 million and, considering the lease payments by the exhibitors, we can assume that a large portion of the cost of the exhibition complex was covered.

The "Mosaeroshow-92" organizers managed to develop the aerospace exhibition complex in a record short period of time (3.5 months). The exhibition complex hardly lags behind the most famous aircraft exhibition complex in the world at Le Bourget (near Paris).

The opportunity that was offered to domestic aerospace enterprises to show their items at "Mosaeroshow-92" completely meets the assigned task to market domestic products. This opportunity is valuable first of all for the producers and developers of aircraft equipment, few of whom are capable of systematically participating in foreign exhibitions.

According to data cited in a KRASNAYA ZVEZDA interview with OKB [Experimental Design Bureau] imeni A.I. Mikoyan general designer R.A. Belkov, in 1991 not a single aircraft from their OKB was sold abroad. A dramatic decline in exports was observed in the entire domestic defense industry in 1991. A certain bias on the part of a number of potential foreign purchasers regarding Russian arms as a result of their unsuccessful employment during the course of the Persian Gulf War is among the primary causes of this, as well as the lack of sophistication of domestic sales structures and possible pressure on the Russian Government by the United States. Exhibitions of the "Mosaeroshow-92" type will help to disperse the bias arising from inadequately thorough analysis of combat operations and knowledge of Russian equipment.

Comparative Statistics of the Largest International Air Shows

	Mosaeroshow-92	Paris-91	Farnborough-90	ILA-92	Dayton-92
Duration of the exhibition, in days	6	11	8	7	6
Number of days for experts	4				4
Total number of firms and organizations	283	1,721	780	460	206
Number of domestic firms and organizations	214		117		184
Number of foreign firms and organizations	69				22
Number of participating countries	11	38	17	23	
Number of aircraft displayed	114	190	115	220	
Number of visitors	280,000	450,000	240,000	300,000	9,000
Total exhibition area, m <sup>2</sup>		382,000	275,000	110,000	889,100
Area of open flight line ramps, m <sup>2</sup>	160,000	147,445			
Area of covered buildings, m <sup>2</sup>	20,000	83,230		40,000	26,570
Number of covered buildings	36		342	60	27

There were 114 aircraft (from super-light aircraft to aircraft armed with strategic missiles, a wide-fuselage passenger aircraft, and the Buran shuttle craft) exhibited at "Mosaeroshow-92", practically exclusively Russian and Ukrainian developments, except for several Czech aircraft and Polish helicopters. There were no Western aircraft. However, many Western firms, while not displaying their products, sent representative delegations to assess the prospects of joint projects with CIS enterprises.

Many items (the Tu-160 and Tu-22M3 strategic bombers, the Yak-41M (Yak-141)—the first supersonic vertical take-off and landing aircraft in the world—the Il-102 ground attack aircraft, the MiG-29K carrier-based fighter aircraft, the Su-27IB fighter-bomber, and the Ka-50 single-seat combat helicopter) were demonstrated for the first time. Models of air-to-air and air-to-surface aircraft weapons, including the latest weapons, and also aircraft equipment were presented and were accompanied by such detailed information for the first time. Demonstrations of domestic PVO [air defense] and PRO [antiballistic missile] missile systems became a sensation.

One of the conclusions that may be reached based on the results of the exhibition is that there are general purpose aircraft in Russia. Recently formed design firms specializing in light motorized aircraft displayed their products along with veteran OKB's that have expanded their sphere of activity, having developed a number of models of general purpose aircraft. We can note an excessive turn toward business aviation to the detriment of PANKh aviation (for employment in the national economy), specifically agricultural aviation, as a "childhood disease" of Russian general purpose aviation.

During the air show on the exhibition's closing day, 130,000 spectators saw group and formation aerobatic maneuvers. Quite a few exotic acts were demonstrated, like the ejection of a manikin in flight at low altitude, low altitude aerial refueling, vertical take-off, and extinguishing a fire from an Il-76. Unfortunately, this also did not occur without losses. During the air show, while ejecting a manikin during take-off at low altitude from the rear cockpit of a Su-7UB aircraft this aircraft was lost (the pilot successfully ejected). Prior to the beginning of the exhibition (on 28 June) during rehearsal of an act involving two Yak-38 aircraft carrying a flag, one of them was also lost due to engine failure and the pilot was automatically ejected when the attitude of the aircraft exceeded permissible limits (at the show the flag was transported by a Yak-38 aircraft and an Mi-8 helicopter). The cause of the engine failure is thought to be hot exhaust gases from another aircraft that were reflected from the ground into the air intake.

"Mosaeroshow-92" permitted Russian experts to expand business contacts with foreign partners. A number of contracts were signed with foreign and domestic aircraft companies. Managers of the OKB imeni A.I. Mikoyan conducted preliminary negotiations

with the British firm GEC Avionics on the possibility of large-scale modernization of the avionics of MiG-21 aircraft, which are widely operated in the world despite their age, signed an agreement on the creation of an SP [joint venture] with a German firm to render assistance in the operation of the MiG-29's that are in the German inventory, and conducted preliminary negotiations on the sale of MiG-29's to Malaysia, and MiG-29's and MiG-31's to Portugal, South Korea, and Switzerland. Attempts to convince Germany to purchase an additional number of MiG-29 aircraft in an improved variant instead of the West European EFA fighter aircraft are continuing. The OKB imeni P.O. Sukhoy also conducted negotiations with South Korea regarding the possible sale of Su-27 fighters, signed a protocol of intentions with Erbas Industries on certification of the Su-26 sports-aerobatics aircraft in France, and signed a contract with the French firm Thomson on cooperation in the sphere of development of onboard and navigation equipment for civil aircraft. A preliminary agreement was reached on the sale abroad of the S-300PMU, S-300V, and Tor ZRK [surface-to-air missile systems].

The signing of an agreement between Russian International Airlines—Aeroflot, the Aviation Complex imeni S.V. Ilyushin, and Voronezh Aircraft PO [Production Association] on the delivery to Aeroflot, beginning in 1995, of 20 Il-96M aircraft equipped with engines from the American firm Pratt & Whitney and equipment from Rockwell-Collins, took place on the day the air show opened (the aircraft's first flight is planned in March 1993 and they propose deliveries beginning in 1995). At the same time, the receipt of an order for three Il-96M aircraft from Uzbek National Airlines was announced. The next day the signing of an agreement took place between Aeroflot, Rockwell-Collins, and the Aviation Complex imeni S.V. Ilyushin for the delivery of the TCASII collision warning system on already operating Il-86 aircraft. And Honeywell, a leading Western firm, formed a new Russian firm named Honeywell Aviation Control Moscow to equip passenger aircraft with the latest flight-control and navigation equipment systems and delivered the first shipment for the new Tu-204 airliner. The former socialist countries and China displayed interest in the exhibition and the restoration of cooperation with these countries is considered possible.

Allied Signal, an American concern that sent the most impressive delegation (30 experts) among Western firms to "Mosaeroshow-92," is already carrying out a number of joint programs with Russian partners, and at the exhibition the firm Bendix, which is part of the concern, signed an agreement with Aircraft Equipment NII [Scientific Research Institute] on joint development and production of avionics for existing and future Russian aircraft. This is the first major joint project of Western and Russian enterprises for aircraft avionics. They initially propose to install liquid crystal displays [ZhKI] developed by Bendix in Il-96, Il-114, and Tu-204 passenger aircraft which are being produced for the Russian domestic market—this should be the first application of

liquid crystal displays on series aircraft. Liquid crystal displays will be utilized as flight regime optimization systems on the listed aircraft. In the future they plan to develop complete flight-control and navigation systems based on liquid crystal displays for the Yak-42M, Yak-46, and Be-200 aircraft.

Allied Signal's projects that have already been carried out jointly with Russia have been associated with other directions of the concern's activities: for example, Garrett, the concern's subsidiary enterprise, has begun to realize a major joint program with Omsk Motor Building Design Bureau [MKB] to develop a new VSU [auxiliary power unit] oriented on Russian aircraft (which have different required air flows than Western aircraft) and that includes Garrett's turbine along with a compressor and other auxiliary components of Omsk MKB. Allied Signal's large-scale presence is associated with the concern's fundamental policy for expansion of cooperation with the CIS as a result of the capacity of the CIS aircraft manufacturing industry and the outlook for its domestic market. In the opinion of Steffenhagen, representative of the concern's Frankfurt department responsible for ties with Russia, an enormous and as yet unrealized potential is hidden in Russian industry. With quite limited technical capabilities, Russian engineers propose solutions that frequently are better than Western solutions. Furthermore, in his opinion, Russia outstrips the West in certain spheres of materials technology.

An agreement on the creation of a scientific-research technical center in the Moscow suburbs, at which they propose employing Russian scientists and engineers, was announced at a press conference organized by the Department of Aviation Industry, Aviaekspost, and Boeing, the largest American aerospace corporation. The joint document was signed on 13 August by Corporation Senior Vice President B. Cosgrove and Department of Aviation Industry General Director A. Bratukhin. It is anticipated that the center will already be able to begin operating in 1993. Initially, five Boeing engineers and approximately 12 Russian scientists will work at the center. In the near future they will have to determine the precise location of the new institution (possibly on the territory of TsAGI [Central Aero-Hydrodynamics Institute]) and compose a list of problems. According to Bratukhin's statement, the possible spheres of research include "promising directions of practical aerodynamics."

## 1. Military Aircraft

### Aircraft of the OKB imeni A.N. Tupolev

#### The Tu-160 Aircraft

The Tu-160 multi-mission strategic bomber, accepted into the inventory in 1985 and is considered to be the best in the world in its class at the present time, was demonstrated for the first time on a ramp and in flight. The bomber was manufactured based upon an integral design with smooth matching of the wing and fuselage. The variable geometry wing ensures flight according to various profiles for the aircraft while preserving high specifications at both supersonic and also subsonic speed. The aircraft has an all-moving vertical and horizontal tail and an analog FBW [fly-by-wire control system]. The power plant consists of four NK-32 TRDDF [turbojet bypass engines with afterburner] engines (4 x 250 kN [kilonewtons]) that are located in two pods under the fixed portions of the wing and have variable air intakes with a vertical panel.

BREO [avionics] includes a strike-navigation system that includes an astronavigation system, INS [inertial navigation system], PrNK [navigation/attack system], and a radar that is designed to detect ground-based and naval surface targets at a great distance, an optical-electronic bomb sight, and improved active and passive electronic warfare systems. The total number of digital processors on board the aircraft exceeds 100. The navigator work station consists of eight TsVM [digital computers].

The bomber is equipped with a probe and drogue aerial refueling system (in the nonoperating position the hose is retracted into the nose section of the fuselage in front of the pilots' cockpit). The crew consisting of four men is seated in K-36DM ejection seats. The crew cockpits are equipped with electro-mechanical displays and displays on ELT [cathode ray tubes—CRT]. There is a sleeping area for pilot crew rest, a toilet, and a galley area to heat food.

Various payloads with a total weight of up to 22,500 kg, including two drum launchers, each of which can carry six strategic cruise missiles with a range of more than 3,000 km, drum launchers each armed with 12 RKV-500B short-range guided missiles, thermonuclear and conventional bombs (including guided), mines, and other weaponry can be located in the two weapons bays.

Comparative Specifications of the Tu-160 and B-1B Aircraft

Type of Aircraft	Tu-160	B-1B
Wing span, meters	35.6/55.7	23.8/41.7
Aircraft length, m	54.1	44.8
Height, m	13.1	10.4
Wing sweep angle, degrees	20/65	15/67.5
Maximum take-off weight, kg	275,000	205,900 <sup>**</sup>
Maximum landing weight, kg	155,000	
Maximum payload weight, kg	45,000	34,000
Type of engines	NK-32	F101-GE-102
Maximum thrust, kN	4x250	4x136
Maximum speed, kph	2,200	1,270
Service ceiling, m	15,000	15,000
Maximum rate of climb, mps	60-70	
Operational range, km	12,300 <sup>*</sup>	10,900 <sup>***</sup>
Take-off run, m	2,200 <sup>*</sup>	
Landing run, m	1,600	
Maximum operational G-load	2.0	
Weaponry:		
Cruise missiles	12 x Kh-55	No <sup>****</sup>
Short-range guided missiles	24 x RKV-500	24 x AGM-64
Bombs	Free-fall	KAB [guided aircraft bombs]

\* With a take-off weight of 275,000 kg.

\*\* Maximum take-off weight 216,370 kg, however, there have not been any reports on flights of aircraft with that take-off weight

\*\*\* With weaponry consisting of eight AGM-64 SRAM guided missiles, eight M61 nuclear bombs, and a PTB [self-sealing fuel cell] with 9,000 kg of fuel in the third bomb bay.

\*\*\*\* In the future, the possibility is being allowed to equip the aircraft with ALCM cruise missiles (eight on a drum launcher and 14 on external suspension points), in this case operational range on an optimal profile will be reduced to 7,200 km.

Structurally, the Tu-160 is close to the American Rockwell B-1B strategic bomber and was accepted into the inventory at approximately the same time as the American aircraft, in comparison with which it has a greater take-off weight and combat payload weight and also higher LTKh [flight technical specifications].

At the same time, special systems directed at reducing the aircraft's radar cross section [RCS] have been more widely employed on the B-1B: fixed-geometry S-shaped air intakes and radar-absorbing coatings that reduce the RCS (the minimum RCS in the course plane is approximately 3 m<sup>2</sup>). At the same time, a more pronounced integral configuration than in the B-1B bomber, low placement of the cockpit, and an all-moving vertical tail, in which the slot between the vertical stabilizer and rudder which increases the RCS has been eliminated, promotes the reduction of the Tu-160 aircraft's RCS.

Unlike the American aircraft, the Tu-160 aircraft is armed both with short-range weaponry and with long-range cruise missiles (they are only proposing to reequip the B-1B aircraft to deliver cruise missiles and also nonnuclear free fall bombs and also guided bombs).

The assembly of Tu-160 bombers is being carried out at Kazan Aircraft Plant. In accordance with the initial plans, they proposed to produce a series of 100 Tu-160 aircraft, however, reports have recently appeared about a reduction, based upon financial considerations, of the number of bombers ordered to 40 (100 B-1B bombers have been built and they plan to build 20 B-2 bombers in the United States).

In the words of CIS Air Force Commander in Chief P.S. Deynekin, under the conditions of economic crisis and restrictions on financing aircraft programs caused by it, long-range aviation needs a cheaper variant of a strategic bomber that has improved operational specifications.

#### The Burlak Aircraft System

One of the possible spheres of employment of the Tu-160 aircraft is its utilization in the Burlak system, which is designed to place light artificial earth satellites into near-earth orbit. The system consists of the Tu-160 mother aircraft and a solid-fueled cruise missile developed at the Raduga MKB [Motor Building Design Bureau].

### Specifications of the Burlak Aircraft System

<b>Weight of a payload placed into low circular orbits:</b>	
Polar, kg	300-500
Equatorial, kg	500-700
<b>Weight of a payload placed into circular orbits with an altitude of 1,000 km or elliptical (with a perigee of 200 km and an apogee of 8,500 km)</b>	
Polar, kg	50-150
Equatorial, kg	120-220
Maximum dimensions of the payload, m	1.9 x 1.2 x 1.2
Volume of the payload compartment, m <sup>3</sup>	1.75

Employment of the aircraft system excludes the need to develop new or lease existing expensive test ranges or ground launch complexes; supports the formation of practically any plane of orbit, execution of launches from any acceptable—from the point of view of ensuring safety—location of the earth, regardless of time of day and climactic or weather conditions; reduces average energy expenditures for the launch of an equivalent payload by a factor of 2-3 in contrast to a ground launch; and also reduces unfavorable impacts on the ecology. The missile preparation devices and the system as a whole are autonomous, mobile, and ensure an efficient launch of a commercial payload.

### The Tu-142M3 Heavy Antisubmarine Warfare Aircraft

The Tu-142M3 heavy antisubmarine warfare aircraft, which is produced at Taganrog and is a modification of the Tu-95 strategic bomber, the first flight of which occurred in 1952 and adoption into the Air Force inventory in 1956, was demonstrated on the ramp.

Besides the Tu-142, the Tu-114 passenger aircraft, the Tu-126 DRLO [AWACS] aircraft, a reconnaissance-target designation aircraft designed for coordination with surface combatants and submarines that are equipped with long-range antiship cruise missiles, an airborne command post aircraft, and also various flying laboratories for developing engines, weaponry, and onboard equipment were developed based on the Tu-95.

The Tu-142M3 aircraft is capable of conducting combat with submarines of all types (including modern nuclear submarines) at a range of up to 5,000 km from the basing airfield, and is equipped with various equipment including a magnetometer, a powerful radar that has 360° surveillance in the lower hemisphere, and a large number of droppable acoustic buoys. There is an onboard ASU [automated command and control system] to process information on targets.

The Tu-142M3 aircraft's weaponry includes antiship guided missiles, torpedoes, and depth charges, and also eight Kh-35 antiship missiles on two underwing pylons. The aircraft is equipped with an aerial refueling probe and flight duration can reach 17 hours. A variant has been developed to equip the bomber with equipment that permits the aircraft to be used to airlift cargoes weighing up to 20 tonnes.

Tu-142 aircraft of various modifications are being used in Russia's naval aviation and are being built at the Taganrog Aircraft Plant. Eight Tu-142M aircraft have been delivered to the Indian Navy.

### The Tu-95MS Bomber

The Tu-95MS Bomber, which was demonstrated in flight, can be armed with six 2,500 km range RKV-15B cruise missiles located on an internal drum launcher and also with nuclear and conventional free fall bombs. The weight of the payload in the bomb bay is 12,000 kg. Defensive weaponry of the Tu-142 and Tu-95MS aircraft includes two GSh-23 cannons that are installed in the tail of the aircraft (the cannon has been standardized with the cannon used on the Il-76 and Il-78 aircraft). Four NK-12MV TVD [turboprop engines] (4 x 15,000 horsepower) are utilized as a power plant. Tu-95MS aircraft are built at an aircraft plant at Samara.

### Specifications of the Tu-95MS Strategic Bomber

Wing span, m	50.0
Aircraft length, m	49.1
<b>Length of fuselage:</b>	
Without aerial fueling probe, m	45.0
With aerial fueling probe, m	46.9
Diameter of fuselage, m	2.9
Aircraft height, m	13.3
Wing area, m <sup>2</sup>	311.1
Maximum take-off weight, kg	185,000
Maximum flying weight (with aerial refueling), kg	190,000
Weight of empty aircraft, kg	90,000
Maximum landing weight, kg	135,000
Weight of fuel, kg	74,000
Maximum speed, kph	910
Maximum Mach speed	0.82
Service ceiling (with six cruise missiles), m	9,100
Operational range (with six cruise missiles), km	11,000
Take-off speed, kph	300
Landing speed, kph	270

A mock-up of the Tu-2000 experimental VKS [spacecraft], designed for flights both in the atmosphere and also in near space, was displayed on the ramp of the NTK [Scientific Technical Combine] imeni A.N. Tupolev. The aircraft is equipped with supersonic PVRD [ramjet engines] installed in a ventral pod and is manufactured based upon a "tail-less" design with a delta wing that has a leading edge wing extension. Liquid hydrogen is used as fuel.

They plan to develop a hypersonic passenger aircraft and also aircraft of other classes based upon the experimental aircraft.

Specifications of the Tu-2000 Spacecraft	
Wing span, m	14
Aircraft length, m	55-60
Maximum take-off weight, tonnes	70-90

### The Tu-22M3 Bomber

At "Mosaeroshow-92" the ANTK [Aircraft Scientific Technical Combine] imeni A.N. Tupolev, TsAGI, and LII displayed an aircraft-laboratory based on the Tu-22M3 bomber (known in the West as Backfire), which is designed for flight research of natural laminarization of sweptwing flow of next generation passenger aircraft. The goal of the tests is:

- to determine the mechanism of the shift of the boundary layer on sweptwings under full-scale Reynolds numbers;
- to more precisely define theoretical developments and improve calculation methods;

- to determine the requirements for manufacturing technology and the quality of the surface of laminarized wings; and,
- to determine the requirements for operating characteristics of laminarized wings under various climactic conditions.

Measurements must be conducted in the Mach range from 0.6 to 0.82; Reynolds numbers  $(14-30) \times 10^6$ ; angles of wing sweep along the leading edge from 17 to 30°; and flight altitudes from five to 10 km. Sections on both outer wing panels have been modified for research. They propose beginning the tests immediately after completion of the exhibition. Pressure distribution, the location of the shift point from the laminar boundary layer to turbulence layer, and surface friction will be determined in flight.

The Tu-22M3 bomber has been in the Russian Air Force and Navy inventory since 1981 and is in series production at the Kazan Aircraft Plant (in accordance with the protocol to the SALT II Treaty between the USSR and United States the rate of production has been restricted to 30 aircraft per year). The Tu-22M3 aircraft and preceding modifications of the Tu-22M and Tu-22M2 are the further development of the Tu-22 bomber and the first long-range bomber with a variable geometry wing.

Specifications of the Tu-22M3 Aircraft	
Wing span, m	34.3/23.3
Aircraft length, m	42.46
Aircraft height, m	11.08
Wing area, m <sup>2</sup>	165
Maximum take-off weight, kg	124,000
Landing weight, kg	78,000
Weight of fuel, kg	50,000
Maximum speed, kph	2,300
Operational range, km	7,000
Combat radius (depending on combat payload and flight profile), km	1,500/2,500
Service ceiling (at Mach 1.3), m	14,000

The aircraft is equipped with NK-25 turbojet bypass engines with afterburner (2 x 250 kN, an NK-22 engine with maximum afterburner thrust of 2 x 220 kN has been installed on the Tu-22M2), a long-range radar that ensures detection of ground-based and naval surface targets, an optical-electronic bomb sight, and an INS. The crew of four men is seated in KT-1 ejection seats. The aircraft has active and passive electronic warfare systems.

Kh-22 guided missiles, designed to destroy naval surface or stationary ground-based targets, are located under the fuselage in a semirecessed position. Another two missiles of the same type are located on underwing pylons. Six RKV-500B short-range guided missiles or their antiship modifications can be placed on a drum launcher in the weapons bay. Bomb weapons with a total weight of up to 24,000 kg are suspended in the weapons bay on two ventral and two underwing multiclamp bomb holders and can include up to 69 bombs of 250 kg or eight 1,500 kg bombs.

Defensive weaponry consists of one modernized GSh-23 cannon (23 mm, 4,000 rounds per minute, two GSh-23 cannons with a rate of fire of 3,400 rounds per minute have been installed on the Tu-22M2) with a remote control system that has television and radar channels.

### Aircraft of the OKB imeni P.O. Sukhoy

#### Variants of the Su-27 Fighter Aircraft

The Su-27K and Su-27UB aircraft, variants of the well-known Su-27 single-seat twin-engine fighter-interceptor, were exhibited on the ramp of the OKB imeni P.O. Sukhoy. The basic Su-27 aircraft and the Su-27IB, one of its latest modifications, were demonstrated in flight.

The Su-27's modern aerodynamic configuration, powerful and efficient bypass turbojet engines, large fuel reserve, broad range of altitudes and flight speeds, highly

effective avionics system, and modern guided missile weaponry ensures its high effectiveness while intercepting airborne targets. Since the very beginning, the Su-27 was developed as the first domestic, statically unstable fighter aircraft with a fly-by-wire control system (FBW) that provides the aircraft's artificial stability for pitch, bank, and yaw. The fly-by-wire control channels are located throughout the entire extent of the aircraft.

A high thrust-to-weight ratio, the availability of the fly-by-wire control system with automatic restriction of the aircraft's permissible angle of attack and the maximum G-load while flying, the adaptive wing, the weapons control system with the use of an optical-electronic radar and helmet-mounted target designation system, and also powerful weaponry permit the Su-27 interceptor to confidently conduct close, maneuvering air combat.

The AL-31F turbojet bypass engine with afterburner, developed at the OKB imeni A. M. Lyulka and installed on the Su-27, is the first world-level bypass engine in our country. The AL-31F operates in a wide range of altitudes and flight speeds and smoothly operates in regimes of a deep surge of the air intake at Mach 2 under conditions of a flat, normal, or inverted spin. The surge elimination systems, automatic engine start in flight, and auto continuous ignition of the primary chamber and afterburner ensure the reliability of the power plant while employing onboard weaponry.

An effective electronic combat system is utilized on the aircraft which consists of the Sorbitsiya-S active jammer (its foreign equivalent is the AN/ALQ-135). Armament consists of a built-in GSh- 30-1 cannon (30 mm, 1,500 rounds per minute, 150 rounds), up to 10 air-to-air missiles, including the R-27 medium-range guided missile and the R-73 close-range guided missile.

In 1986-1988, 27 time-to-climb and horizontal flight altitude world records were set in the interceptor variant of the Su-27 that has the designation P-42 (with R-32 turbojet bypass engines with afterburner, 2 x 133.37 kN, 2 x 136 kN).

The year 1969 marks the beginning of the development of the aircraft and the first flight of the T-10-1 prototype aircraft occurred on 20 May 1977. The Su-27 has been in the Russian Air Force inventory since 1984. In 1991, as a result of budget restrictions, the Air Force decided to develop a base Su-27 and develop a reconnaissance aircraft, a fighter-bomber, a jammer, an all-weather

interceptor, etc. based upon it, to concentrate resources on combat aircraft, and to prevent the development of various types of aircraft with identical missions, and ceased purchases of MiG-29 aircraft.

In August 1992 the first Su-27 aircraft of a shipment of 24 aircraft were transferred to China within the framework of a \$1.5 billion contract at a price of \$35 million per equipped aircraft. This is the first delivery of Russian weaponry to China in the last 30 years. Russian military instructor-pilots were to have provided retraining of 200 Chinese pilots for this type of aircraft, however, the Chinese refused the services of the Russian Air Force, explaining that they have their own instructors who underwent flight training in the Su-27 at a CIS aviation school. The Su-27 has been series produced at Komsomolsk-na-Amur since 1982 and the Su-27UB at Irkutsk since 1986.

A coherent pulse-Doppler jam-proof radar, which has the capability to search and track targets in the background of the underlying surface, has been installed on the Su-27 (it provides track-while-scan and the simultaneous launch of guided missiles against two targets). A 36Sh optical radar system, developed at the Geofizika NPO [Scientific Production Association] and slaved to the helmet-mounted target designation system, supplements the radar and was demonstrated at the exhibition. The system is designed to determine the coordinates of contrasting thermal mobile targets and has the following technical specifications:

**Specifications of the 36Sh Optical Radar System**

Search field, degrees	120 x 75
Field of view, degrees	60 x 10
Detection range, km	
In the rear hemisphere	50
In the forward hemisphere	15
Range measurement range, km	0.3-3
Coordinate measurement accuracy	
for azimuth, in minutes	5
for range, in meters	10
Angular velocity of automatic tracking, degrees per second	more than 25

The specifications of the Su-27 aircraft variants that were demonstrated at the exhibition are presented in the following table.

Comparative Specifications of Su-27 Aircraft Variants

	Su-27	Su-27IB	Su-27K	Su-27UB
Year of first flight	1977	1990	1987	1985
Year accepted into the inventory	1984			
<b>Dimensions:</b>				
Wing span, m	14.7	not available	14.7	14.7
Aircraft length, m	21.935	not available	21.935	21.935
Aircraft height, m	5.932	not available	5.932	6.337
Wing area, m <sup>2</sup>	62	not available	62	62
Wing sweep, p/k [leading edge], degrees	42	not available	42	42
Crew, men	1	not available	1	2
<b>Engines:</b>				
Number	2	2	2	2
Model	AL-31F	AL-33K	AL-31F	AL-31F
<b>Thrust, kN:</b>				
With afterburner	2 x 122.58	2 x 125.53	2 x 122.58	2 x 122.58
Without afterburner	2 x 74.53	not available	2 x 74.53	2 x 74.53
<b>Weight and payload, kg</b>				
<b>Take-off weight</b>				
Maximum	30,000	44,360	32,000	30,500
Normal	22,500	not available	not available	24,000
Empty aircraft	16,000	not available	not available	17,500
Maximum combat payload	6,000	8,000	6,000	not available
Internal fuel	9,400	not available	not available	not available
<b>Flight data:</b>				
<b>Maximum flight speed, kph:</b>				
At high altitude	2,500	not available	2,300	2,125
At sea level	1,400	not available	not available	not available
Maximum Mach number	2.35	not available	2.17	2.0
Service ceiling, m	18,500	not available	17,000	17,250
Maximum range, km	3,900	4,000	3,000	3,000
Take-off run, m	650	not available	not available	750-800
Landing speed, kph	not available	not available	240	not available
Landing run, m	620	not available	not available	650-700
Maximum operational G-load	9	not available	8	9

The Su-27UB is a combat trainer fighter aircraft designed to retrain pilots into the Su-27 aircraft; it retains all the combat capabilities of the Su-27 (the weapons and weapons control systems have been completely preserved), and provides an outstanding field of view to the pilots from both cockpits. The seats are located in tandem in the two-seat cockpit. Series production has begun of an Su-27UB modification that is equipped with an aerial refueling system. In 1988 a Su-27UB completed a flight from Moscow—Komsomolsk-na-Amur—Moscow, a distance of 13,440 km, with four aerial refuelings and without landing.

The Su-27IB is a two-seat fighter-bomber with the seats located side by side. It is designed to destroy heavily

defended point targets in any weather conditions, during the day or at night. It is capable of completing a flight in the terrain following mode. The Su-27IB is designed to replace the first variants of the Su-24 aircraft. It is similar to the American McDonnell-Douglas F-15E fighter-bomber. The Su-27IB took off for the first time on 13 April 1990 (test pilot A. Ivanov). It was publicly demonstrated for the first time at Machulishchi Airfield (near Minsk) during a meeting of the CIS member-states heads of state on 13 February 1992. At least two more years will be required to complete aircraft flight tests. The Su-27IB has an integral aerodynamic configuration and is manufactured according to a "triplane" with PGO [foreplanes] design. It is also distinguished by the utilization of a twin-wheel nose gear and reinforced main

landing gear, and it does not have ventral fins. The cockpit is an armored capsule with the employment of a titanium alloy and armored glass, entry into the cockpit is through a folding ladder in the forward landing gear well. The cockpit is equipped with multifunction cathode ray tube displays and the seats are distinguished by their improved ergonomics. Approximately 30% of the weapons control system has been modified to support aircraft operations against ground-based targets.

The aircraft can be armed with two Kh-31 antiradiation missiles on suspension points under the engine air intakes, 500 kg laser-guided bombs on internal underwing pylons, Kh-29T television-guided and Kh-29L laser-guided air-to-surface guided missiles on the middle underwing pylons, with RVV-AE medium range air-to-air missiles on the external underwing pylons, and with R-73 infrared seeker dogfight missiles on the ends of the wing. KAB-150 and UAB-500 bombs can be installed (the bombs have laser, television, or infrared guidance). Guidance of the Kh-29 guided missiles can be carried out using the helmet-mounted system. The 30 mm cannon has been retained in the starboard wing root extension and a retractable aerial refueling probe has been located in the port wing root extension. The aircraft's nose fairing has a flattened shape with developed side extensions and tapered edges. The nose fairing was manufactured from metal and was not equipped with instruments in the test model of the aircraft that was demonstrated. In the future, they propose installing a radar with a small antenna in it.

The Su-27K is a carrier-based fighter aircraft for defense of Navy ships from enemy offensive air weaponry. Work on the development of the carrier-based variant of the Su-27 aircraft began in 1977, the first flights of the Su-27 aircraft from a ground-based ski jump took place in the summer of 1982, and the first landing of a Su-27 on an arresting gear occurred on 1 September 1985. The first flight of the Su-27K (T-10-1) test model occurred on 17 August 1987 (V.G. Pugachev). On 1 November 1989, the Su-27K carried out a landing in aircraft fashion on the deck of the Admiral of the Fleet of the Soviet Union Kuznetsov heavy aircraft-carrying cruiser for the first time in the USSR and took off from the ship's deck using a ski jump. They proposed demonstrating the Su-27K for the first time in the West at the 1992 Berlin Aerospace Exhibition. The pre-series-production model was demonstrated at "Mosaeroshow-92." Completion of state testing was noted in July 1992 and the decision was made on series production. According to unofficial data, a contract has been concluded on the export sale of the Su-27K.

The Su-27K is manufactured based upon the "triplane" with PGO design that significantly expands the aircraft's maneuvering capabilities. The fighter is equipped with a folding wing and stabilizer. Automatically deflected wing leading edge mechanization permits it to carry out flights through an envelope of the drag polars, and the developed mechanization of the trailing edge increases lift by a factor of 1.5 during landing and substantially reduces landing speed. The cockpit seat has an increased

angle of incline. The flight-navigation system provides automatic flight until touchdown on the ship's deck. The retractable aerial refueling probe is located ahead of the cockpit on the left side. The optical-electronic radar is located on the right if you are looking out from the cockpit (on the initial Su-27 it has a central location). The aircraft has a multichannel communications system and a developed electronic countermeasures system.

Besides the built-in 30 mm cannon, the Su-27K's weaponry includes the Moskvit long-range supersonic anti-ship guided missile (located on a ventral suspension point on a special tray) and up to 10 air-to-air missiles. The LII demonstrated a flying laboratory on the ramp that was developed based on the Su-27 aircraft to study active flight safety support systems of future maneuvering aircraft and optimal control of their trajectory movement. The flying laboratory is being utilized as part of the LMK-2405 flight-modeling system that also includes a ground test-adjustment stand. The flying laboratory is equipped with a complex control system that combines an experimental aircraft and engine control system and an experimental information and control element depiction system. Omnidirectional information exchange system is utilized for communications with a ground station. The flight test control system supports processing of external trajectory changes, radio-telemetry information, and also modeling and formation of the laws of control utilizing a ground stand.

Six Su-27 aircraft are part of the "Russian Warriors" acrobatic team that performs with success in Russia and abroad. Test pilot A. Kvochur, who performed at "Mosaeroshow-92" with demonstration flights in the Su-27, recently organized a new acrobatic team which is equipped with four Su-27 aircraft (two single-seat and two twin-seat aircraft with an aerial refueling system) that were painted using Western-manufactured paint. The aircraft were purchased at the plant (single-seat aircraft at Komsomolsk-na-Amur) at a price of \$50 million per aircraft. The private insurance company Jupiter provided the funds for the acquisition of the aircraft.

#### **The Su-24MR Reconnaissance Aircraft**

The Su-24MR specialized reconnaissance aircraft that was demonstrated for the first time was exhibited in Russian tricolors at the ramp of OKB imeni P.O. Sukhoi. This aircraft was developed based on the Su-24M frontal aviation bomber, has a variable swept wing, and is designed to provide reconnaissance information to ground troops and frontal aviation commanders and, on maritime axes, to the Navy. It can carry out comprehensive all-weather aerial reconnaissance during the day and at night in a wide range of altitudes and speeds to a depth of 400 km beyond the line of contact under the impact of enemy PVO [air defense] weapons systems. To carry out reconnaissance missions, the aircraft is equipped with the BKR-1 reconnaissance system which ensures a high probability of detection and identification of military equipment targets, including decoys and camouflaged targets. The Su-24MR aircraft can be

employed for civilian purposes to assess radiation contamination of terrain and air near AES's [nuclear power plants], detection of spills of petroleum products on the ground and in the water, monitoring the state of forest areas and detection of forest fires, terrain mapping, etc.

Cameras for panoramic and oblique photography, a radar system, infrared and television reconnaissance have been installed onboard the aircraft and laser, radio-technical, and radiation reconnaissance equipment are located in removable external pods. The reconnaissance systems are controlled automatically and manually. The onboard navigation equipment supports the flight of the aircraft along a preprogrammed route, aircraft entry into the reconnaissance sector, and low-altitude flight with collision warning and fly around of obstacles.

The Shtyk side-looking radar, developed at Vega-M MNIIP NPO, has been installed in the aircraft nose section and the Krasnogorsk Plant-produced AP-402M panoramic camera—in the lower section, the A-100 oblique AFA [aerial camera] of that same plant—in the lower section of the fuselage right behind the cockpit, and the Geofizika NPO-developed infrared system—in the lower central section of the fuselage. A pod with the Shpil-2M laser device, developed at the radio optics scientific research institute, is hung on the central ventral suspension point, and a pod with the Efir-1M radiation reconnaissance device—on the right external underwing suspension point.

The Shtyk radar provides a view of a zone that is 24 kilometers wide on each side from the line of flight with an 8 kilometer-wide nonviewed section (directly under the aircraft), a flight altitude of 100-3,000 meters during radar reconnaissance, and resolution of 5-7.5 meters.

#### Specifications of the Su-24MR Aircraft

<b>Dimensions:</b>	
<b>Wing span at sweep angle:</b>	
16°, m	17.63
69°, m	10.36
Aircraft length with the pitot tube, m	24.53
Aircraft height, m	6.19
<b>Wing area at sweep angle</b>	
16°, m <sup>2</sup>	53.16
69°, m <sup>2</sup>	51.0
<b>Engines:</b>	
Number	2
Type	Saturn NPO AL-21F3A
<b>Stand thrust</b>	
At full afterburner, kN	2 x 112
At maximum regime, kN	2 x 78
<b>Weights and payloads:</b>	
<b>Take-off weight</b>	
Maximum permissible, kg	39,700
Normal, kg	33,325
<b>Landing weight</b>	
Extreme, kg	28,000
Maximum, kg	26,000
Normal, kg	23,035
Capacity of internal fuel tanks, liters	11,700
<b>Flight data:</b>	
Mach flight number at high altitude	1.35
<b>Maximum flight speed at an altitude of 200 m</b>	
Without external fuel tanks, kph	1,320
With the Shpil-2M and Efir-1M pods and with two R-60 missiles, kph	1,200

### Specifications of the Su-24MR Aircraft (Continued)

Combat radius during a flight at an altitude of 200 m with variable speed (670 kph in the section 200 km from the line of contact, 900 kph during the remaining section) with the Shpil-2M and Efir-1M pods and with two R-60 missiles when the missiles are dropped at the halfway point

Without external fuel tanks, km	420
With two 3,000 liter capacity external fuel tanks and dropping the external fuel tanks after the fuel has been consumed	650
Ferry flight range along the most advantageous profile with two 3,000 liter capacity external fuel tanks (with dropping of the external fuel tanks after the fuel in them has been consumed)	
Without aerial refueling, km	2,500
With one aerial refueling, km	4,360
Maximum operational G-load	6.5
VPKh [take-off and landing specifications] on a BVPP [concrete runway] with a wing sweep of 16°, flaps set at 34° and slats at 27°	
Take-off run at normal take-off weight, m	1,100-1,200
Landing run at normal landing weight with brake chute and wheel braking, m	1,000-1,100

There are no aircraft similar to the Su-24MR reconnaissance aircraft among foreign frontal aviation reconnaissance aircraft based upon comprehensiveness of the reconnaissance information obtained. For example, AN/AAS-18 infrared equipment, the AN/APQ-102 side-looking radar, and several aerial cameras for mapping and oblique photography from high and low altitudes are utilized on the RF-4C aircraft that make up the foundation of U.S. Air Force tactical reconnaissance aviation; the AIL AN/ALQ-61 or Litton AN/ALQ-25 pod systems are utilized for SIGINT reconnaissance, but there are no laser or radiation reconnaissance systems, and the American reconnaissance aircraft is lighter and, with a fixed swept wing, substantially lags behind the Su-24MR in flight range and speed at low altitudes. Based upon flight specifications, the British GR.1A Tornado reconnaissance aircraft, which was also modified from a fighter bomber with a variable sweep wing, approximates the Su-24MR but the GR.1A Tornado was conceived as a reconnaissance aircraft with retention of combat capabilities and is equipped only with the TIRRS panoramic and side-looking infrared reconnaissance system instead of cannons.

The collected photo information is delivered by dropping photo materials that have been exposed on board and the remaining reconnaissance information is efficiently transmitted to the ground via wideband and narrow band radio channels. All information is supplied with navigation data for tying it in with aircraft location coordinates and time. Reception, processing, and decryption of the obtained reconnaissance information at the ground site is conducted in real time. On the British GR.1A Tornado, the reconnaissance information received is recorded on videotape and can be reproduced on a small TV display in the navigator-operator's cockpit in near real time (the Tornado is the first aircraft in the NATO countries' air forces with this capability), however, during the Persian Gulf War in 1991, navigators rarely utilized the capability to monitor reconnaissance

information because they were completely loaded down with carrying out navigation tasks and with monitoring the threat from enemy surface-to-air missile complexes.

External fuel tanks with a capacity of 3,000 liters each have been installed on the Su-24MR aircraft's internal underwing suspension points, two R-60 (AA-8 Aphid) close-range infrared seeking air-to-air missiles (for self-defense) have been installed on the left external underwing suspension point.

### The Su-25 Ground Attack Aircraft

The new Su-25TK aircraft was demonstrated at "Mosaeroshow-92." It was developed at the ANPK imeni P.O. Sukhoy based on the Su-25 ground attack aircraft which is being widely utilized by the air forces of the CIS countries, Czechoslovakia (50 ground attack aircraft have been delivered), Hungary (50), Iraq (25), the DPRK (20), and Syria (60), and has been produced at Tbilisi Aircraft Plant since 1976.

The first Su-25T flight took place in August 1984. By the end of 1991, eight of the 10 ordered test ground attack aircraft had been built. Series production of the aircraft is being established at a plant in Ulan-Ude.

The ground attack aircraft's fuselage approximates the configuration of the fuselage of the Su-25UB two-seater combat trainer aircraft. The avionics are located in a large capacity fuselage fairing. An increased capacity fuel tank that is screened by the engines from the sides has been installed in the central section of the fuselage. The experience of combat employment of Su-25 ground attack aircraft in Afghanistan has been realized in the aircraft design: the central section of the fuselage has been reinforced and the engines' IR signature has been significantly reduced.

Two Ufa Engine Building Production Association R-195 TRD [turbojet engines] (2 x 45 kN) have been installed on the Su-25T, which have increased thrust in contrast to the initial engines.

### Specifications of the R-195 Turbojet Engine

Length, mm	7,880
Diameter, mm	805
Diameter of the outlet section of the nozzle, mm	547
Dry weight, kg	860
Maximum thrust, kN	45
Average fuel consumption, kg/kg per hour	0.89
Temperature of the gas in front of the turbine, °C	930
Air consumption, kg per second	66
Degree of air pressure increase	9

It has an automated aircraft control system that ensures access to the target in simple and complex weather conditions at any time of the day with high accuracy.

The ground attack aircraft is equipped with an I-251 weapons aiming system that was developed by Krasnogorsk's Zenit OMZ for automatic identification and automatic tracking of small targets (tanks, motor vehicles, small craft, etc.), transmission of target designation and automatic guidance of guided missiles, and also for fire control.

The system consists of the Shkval day optical-electronic system located in the nose section of the aircraft, which includes television channels with fields of view of  $27 \times 36$  and  $0.7 \times 10^\circ$  and 23-fold magnification, and also a laser rangefinder-target designator installed on a single platform that is stabilized for pitch, bank, and yaw and have angles of vertical guidance in a range from  $+15^\circ$  to  $-80^\circ$ , and horizontal guidance from  $+35^\circ$  to  $-35^\circ$ . Furthermore, the system also has automatic target tracking and target designation systems, guided missiles with self-homing, control of antitank guided missiles using laser guidance, sighting line stabilization, and a BTsVM [onboard digital computer]. For operations at night the I-251 system can be supplemented by the Mercuriy IR-imaging system, which is mounted in a pod installed on an external ventral suspension point. The pod's cross section is close to a right angle and its forward portion is covered by a hatch that protects the optics during take-off and landing. The IR system has a lens with wide and narrow ( $5.5 \times 7.3^\circ$ ) fields of view (the night channel's optical system is not stabilized). Detection range and target lock-on by the day channel television system is 10 km, the night system—somewhat less.

Video information of the day television channel and night channel with a narrow field of view is displayed on a monochrome CRT that has been installed in the right upper portion of the aircraft cockpit instrument panel and the night channel with the broad field of view—on an ILS [head-up display—HUD].

The process of navigation and attacking a target has been automated to the maximum extent possible by the Su-25T. The aircraft automatically enters the target area, the television system, oriented beforehand in the required direction, begins to operate 10 km from it, then

the pilot carries out monitoring of the selection and lock-on of the target, after which the system shifts to automatic tracking. After the pilot presses the combat button, the system carries out selection of the required munitions and conducts their launch. After the first run to the target, the aircraft can carry out a repeat run in the automatic mode or, based on the pilot's desire, return to base (the pilot can take control of the aircraft only directly prior to landing).

Based on the assessments of OKB imeni P.O. Sukhoy representatives, the Su-25TK aircraft with the I-251 weapons aiming system outstrips similar developments abroad by five to six years (only one foreign single-seat aircraft—the General Dynamics series 40 F-16C fighter-bomber—is being equipped with the LANTIRN optical-electronic system).

The Su-25T's defensive systems consist of an ELINT reconnaissance system, identification, suppression, and destruction of radars, and dispensing chaff using missiles with IR and radar guidance. Pods with 192 IR decoys and chaff and also an IR jamming generator in the tail section of the ground attack aircraft under the vertical stabilizer have been installed on the aircraft.

The Su-25TK aircraft's weaponry consists of Kh-58 antiradiation guided missiles (in the future, they propose equipping it with the more powerful Kh-31P antiradiation missile), the Kh-25ML guided missile with a laser guidance system, and also the Vikhr antitank system which, according to the assertions of OKB representatives, has no equals in the world. The missile with a high supersonic speed and launch range of up to 10 km has a tandem shaped-charge warhead that is capable of piercing modern multilayer or active armor with an equivalent thickness of up to 1,000 mm (the guided missile can destroy the most powerful American M-1A2 Abrams tank in the forward projection). Thanks to the missile's high speed, several targets can be destroyed in a single run. An APU-8 aircraft launcher contains eight Vikhr guided missiles in a transport-launch canister that is hung under the aircraft wing.

The Su-25TK aircraft's typical combat load is 16 Vikhr guided missiles.

The guided missile's high specifications permit the complex to be employed not only against ground-based but also against airborne targets (a videotape that was shown during the exhibition showed how a Vikhr guided missile destroyed a Tu-16 target-aircraft in the air).

### Specifications of the APU-8

Length, mm	1,524
Width, mm	720
Height, mm	436
Weight of the unloaded device, kg	60
Weight of the loaded device, kg	535
Number of missiles in the APU	8

The Su-25TK aircraft that was displayed on the ramp was armed with a new guided missile with a laser guidance system that was developed based on the S-25 heavy NAR [unguided rockets].

Besides guided missile weapons, the ground attack aircraft can be equipped with 80-370 mm unguided rockets, conventional and guided aircraft bombs, and air-to-air missiles with an IP guidance system.

Built-in weaponry consists of a 30 mm cannon installed in the open under the fuselage (in contrast to the GSh-302 cannon employed on the Su-25 aircraft, the new gun supports a round with a higher muzzle velocity, and has greater range and firing accuracy).

The Su-25T was demonstrated for the first time at the international air exhibition in the Principality of Dubai (Arabian Peninsula) in the autumn of 1991.

#### Specifications of the Su-25TM Aircraft

Wing span, m	15.33
Aircraft length, m	14.52
Height, m	5.20
Maximum take-off weight, kg	19,500
Weight of fuel in internal tanks, kg	3,840
Maximum combat payload, kg	4,360
Number of weapons suspension points	10
Maximum speed, kph	950
Service ceiling, m	10,000
Range of combat employment altitudes, m	30-5,000
Maximum operational G-load	6.5
Operating range with a 2,000 kg combat payload:	
At sea level, km	400
At altitude, km	700
Ferry range with external fuel tanks, km	2,500
Take-off and landing run on a dirt runway, m	600-700
Firmness of the ground of the dirt runway, kg/cm <sup>2</sup>	5-6

#### Aircraft of the OKB imeni S.V. Ilyushin

##### The IL-102 Ground Attack Aircraft

The IL-102 prototype ground attack aircraft developed at the OKB imeni S.V. Ilyushin was displayed at the exhibition for the first time. Work on the program began in the mid-1970's and was conducted simultaneously with the development of the T-8 (Su-25) aircraft at the OKB imeni P.O. Sukhoy. The IL-102 ground attack aircraft is the further development of the IL-40, the first Soviet ground attack aircraft with a turbojet engine, developed in 1953. Two IL-102 aircraft were built, one of which was intended for the conduct of static tests. The ground attack aircraft's first flight took place in 1982 and pilots S.G. Bliznyuk and V.S. Belousov conducted the flight tests (more than 200 flights were conducted). The

aircraft underwent state testing; however, a decision on series production was not made, which is partially explained by the presence in the Air Force inventory of the Su-25 aircraft, which has similar characteristics.

The IL-102 ground attack aircraft was manufactured according to a normal aerodynamic design with a low swept wing. The IL-40 aircraft's specific configuration features were preserved: the crew, consisting of two men, and the fuel tanks and two engines located in an armored box in the central section near the aircraft's center of mass, which permitted them to decrease the area of armor and improve the ground attack aircraft's maneuvering characteristics.

The aircraft's wing is swept and has a relatively thick section permitting six bomb compartments to be "inscribed" into the wing near the root section which are capable of accommodating munitions of up to 250 kg (the diameter of a bomb must not exceed 325 mm). The wing tips have been canted downward (a place has been provided for installing pods with IR decoys in their facing portion). It has simple twin-section flaps. The ailerons have a pointed leading edge and trim and balance tabs. Twin-section spoilers have been located in the wing's upper surface. The stabilizer is equipped with a horn-balance elevator tab and trim and balance tabs. The swept tail fairing with a developed dorsal fin has a rudder with horn balance and triple-section servo balance.

The fuselage has a characteristic "hump" in which the pilots' and gunner's cockpits, part of the avionics equipment, and the fuel tanks are located (large removable panels that facilitate access to the equipment are located between the pilots' and gunner's cockpits). Two speed brakes have been installed in the tail section along the sides of the fuselage. The forward and rear cockpits have flat armored glass. Cockpit equipment is traditional with electromechanical instruments equipped with circular scales. The tricycle landing gear provides the capability to operate the aircraft from dirt runways that are capable of supporting a specific pressure of 5 kg/cm<sup>2</sup>. The rearward retracting single-wheel nose gear (5th model tire, 70 x 330) is set far ahead and provides good anti-nose-over characteristics. It has twin-wheel primary landing gears with model 10A tires (930 x 305) that are retracted into a fairing under the wing.

A total of 4,000 kg of fuel is located in six tanks located in the central portion of the fuselage and protected by armor. Two external fuel tanks weighing 800 kg each can be installed on two ventral external suspension points. The aircraft's power plant consists of two RD-33I turbojet bypass engines (2 x 52 kN, a non-afterburner variant of the RD-33 turbojet bypass engine with afterburner that is installed on the MiG-29 fighter aircraft). They propose the employment of a thrust vector deflection and reverse system.

An S-17BTs collimating gunsight has been installed in the pilot's cockpit and the possibility of utilizing a radar gunsight and optical-electronic sighting systems has been

provided for. The gunner is equipped with a KPS-53-A weapons aiming system that includes a PAU-475-2M gunsight with a range finder and computer. K-36L ejection seats, developed at Zvezda OKB under the leadership of G. Severin, have been installed in the aircraft.

Cannon weaponry consists of a twin-barrel 30 mm cannon that turns in the vertical plane with a combat load of 500 rounds and a GSh-23 rear defensive cannon on a mobile turret (23 mm, 60 rounds) that is remotely controlled by the gunner. Missile-bomb weaponry with a total weight of 7,200 kg is located on 16 suspension points (including on six internal wing suspension points) and includes R-60M and R-72 air-to-air guided missiles with IR guidance, 100-500 kg aircraft bombs, pods with various types of unguided rockets, canisters for small cargoes, and other weaponry.

#### Specifications of the Il-102 Aircraft

Wing area, m <sup>2</sup>	63.5
Normal take-off weight, kg	18,000
Maximum take-off weight, kg	22,000
Weight of fuel in internal tanks, kg	4,000
Weight of combat payload, kg	7,200
Maximum speed, kph	950
Minimum control speed, kph	250
Landing speed, kph	180
Lift-off speed, kph	150
Combat radius, km	400-500
Ferry range, km	3,000
Take-off run, m	250-300
Landing run, m	400-450
Landing run with turbojet bypass engine reverse thrust, m	300-350

#### Aircraft of the OKB imeni A.I. Mikoyan

##### Variants of the MiG-29 Fighter Aircraft

Besides the well-known modification of the MiG-29 frontal aviation fighter based upon previous demonstrations, two new variants were displayed for the first time at "Mosaeroshow-92": The MiG-29KVP and the MiG-29K.

The TTT [tactical-technical specifications] for the MiG-29 aircraft were published in 1972, the technical design began in 1974, and the first of 11 prototype aircraft built completed its first flight on 6 October 1977. Series production began in 1982 and was carried out at plants in Moscow (MAPO) and Nizhny Novgorod. The MiG-29 began to enter the inventory in 1983. Over 500 aircraft were in the inventory of the countries of the former USSR by the beginning of 1992. Furthermore, the MiG-29 has been supplied to Cuba, Czechoslovakia, the GDR, India, Iran, Iraq, North Korea, Poland, Romania, Syria, and Yugoslavia.

#### Specifications of the MiG-29

<b>Wing span, m</b>	
MiG-29	11.36
MiG-29K (folded/deployed)	7.8/12.0
<b>Aircraft length, m</b>	
MiG-29	17.32
MiG-29K	17.27
Aircraft height, m	4.73
Wing area, m <sup>2</sup>	38
Crew	1 man
<b>Engines: Number and type</b>	
MiG-29	2 SPNPP [St. Petersburg Scientific and Production Enterprise] imeni V.Ya. Klimov RD-33 turbojet bypass engines
MiG-29K	2 SPNPP imeni V.Ya. Klimov RD-33K turbojet bypass engines
<b>Maximum afterburner thrust, kg</b>	
MiG-29	2 x 8,300
MiG-29K	2 x 9,400
<b>Weight and payload: Take-off weight Maximum, kg</b>	
MiG-29	18,480
MiG-29K	17,700
Normal, kg	15,240
Combat payload, kg	3,000
<b>Flight data: Maximum flight speed At high altitude, kph</b>	
MiG-29	2,450 (Mach 2.3)
MiG-29K	2,300 (Mach 2.2)
At sea level, kph	1,300
Service ceiling, m	18,000
<b>Rate of climb at sea level, meters per second</b>	
MiG-29	330
MiG-29K	260
<b>Maximum flight range, km</b>	
MiG-29 with one external fuel tank	2,100
MiG-29K with external fuel tanks	2,600
<b>Take-off run, m</b>	
Without afterburner	600-700
With afterburner	260
Length of runway for the MiG-29K at normal and maximum take-off weight, m	120-200
Landing run, m	600
Maximum operational G-load	9

**Specifications of the MiG-29 (Continued)**

MiG-29K angle of departure from a ski jump during take-off, degrees	15
Maximum permissible braking load	
MiG-29K from the arresting gear	-4.5
MiG-29K landing speed, kph	230
MiG-29K nominal direct landing glide path angle, degrees	-4.0

The MiG-29KVP is an intermediate variant built to work out take-off from a ski jump and landing on an arresting gear. It can be utilized both as a combat aircraft or as a training aircraft for carrier aviation pilots at ground-based airfields. The only difference from a normal ground-based aircraft is the arresting hook and the reinforced design.

The MiG-29K is a carrier-based fighter-bomber. Its testing began during operations from the deck of the Admiral of the Fleet of the Soviet Union Kuznetsov heavy aircraft-carrying cruiser in November 1990. It has a folding wing, arresting hook, and structurally reinforced landing gear and fuselage tail section. The doors of the air intake foreign object protection system that were used on previous variants of the aircraft have been replaced with lighter retractable grates and the auxiliary upper air intakes have been removed and additional fuel tanks have been installed instead of them; still, the walls of the air intakes in the landing gear well area have been perforated to improve foreign object protection of the air intakes. The wing has eight load-bearing suspension points. The new Zhuk radar is located in the nose fairing with a new, single curvature profile. There are no over-wing dorsal fins in which packages of chaff and IR flares were previously located. The aircraft that was displayed had Kh-31 antiradiation missiles on internal pylons and R-73 air-to-air missiles on internal pylons [as published].

The overall architecture of the weapons control system is just like on the initial ground-based MiG-29. There are no similar weapons control systems abroad, and there is no similar optical radar equipment which operates autonomously and along with other onboard systems. The MiG-29K has a new optical-electronic radar, improved sensor cooling, and increased target detection range. It has an aerial refueling system, the intake probe of which is located on the port side ahead of the cockpit.

The Zhuk multifunction onboard radar was developed by the Fazotron Concern. It has high effectiveness and reliability with comparatively low weight and can operation in the "air-to-air" and "air-to-surface" modes. The Zhuk radar mock-up was shown for the first time at the 1989 Paris Air Show. By the summer of 1992, 10 prototype radars had been built and flight tests are nearing completion. In the words of Fazotron Deputy Chief Designer V. Antonov, the Zhuk radar is lighter than the radar installed on the MiG-29 at the present

time, is linked with additional weaponry, has a track-while-scan mode, and is capable of supporting simultaneous firing against up to four targets using missiles with active guidance (the existing MiG-29 aircraft radar permits attacking only one target at a time).

In June 1991, an operational and technical assessment of the MiG-29 aircraft was completed in Germany and the German Ministry of Defense announced its intention to retain in the inventory the 20 MiG-29 single-seat air superiority fighters and four MiG-29UB two-seat trainer aircraft that had been previously delivered to the GDR. It is assumed that they will be operated until approximately 2002, each of which will have 2,500 flying hours by that time. In addition to the initial role of ensuring the air defense of the eastern sector of Germany from Preschen Airfield near the border with Poland, the MiG-29 aircraft of JG9 Squadron will be utilized as simulated enemy aircraft during Luftwaffe and other NATO forces exercises. MiG-29 and F-15 and F-16 air combat training has been conducted, including in the autumn of 1990 within the framework of preparing for the war with Iraq.

In the opinion of Lieutenant General H.-J. Kubart, German Air Force commander in chief, the MiG's can operate normally until 2002-2003, although he also expressed his concern about supplying the German MiG-29 squadron with spare parts. The low service life of the early model RD-33 engines that were installed on them (the mean time between repair equals only 350 hours, but total service life can total 600 hours) is cited among the shortcomings of the German MiG-29's. As a result, a low MiG-29 readiness coefficient was noted in the first stage of mastering the aircraft in the FRG: only six of 24 aircraft were combat ready in December 1991. In January 1992, the level of combat readiness was doubled but was still inadequately high. Representatives of the Russian plant who service the engines and guarantee an increase of service life by 50-100 hours were sent to the FRG.

The Finnish Air Force organized a competition for a new fighter aircraft in 1991-1992. The Mirage 2000-5, the JAS-39, the F-16, and the F/A-18 aircraft participated in it and the MiG-29 fighter aircraft was viewed as a fifth "shadow" candidate. In the words of Major General H. Nikunen, Finnish Air Force commander in chief, the MiG-29 has good flight specifications but inadequately high efficiency and operating technology. Furthermore, the general expressed doubts in Russia's capability to provide the aircraft with spare parts and offer the required barter compensations (the Finnish side will pay for the entire shipment of aircraft with counter deliveries of their own goods).

Since 1991, further deliveries of MiG-29's to the Soviet Air Force have been terminated in order "to prevent many types of aircraft with an identical mission." But production for export is possible. Export sales attempts through intermediaries are well known. The lack of sophistication of domestic sales structures is one of the causes of the poor aircraft sales (in the words of General Designer R.A. Belyakov, not a single aircraft was sold

abroad in 1991, although there are more than 50 undelivered MiG-29's at MAPO worth approximately \$1 billion). To improve the situation, the KB [design bureau] has organized the firm MIGservis, uniting the KB with the Znamya truda manufacturing plant and cooperating with only one foreign trade organization which must issue the license for aircraft sales. It is assumed that the developer will have definite proceeds from the sale of the aircraft. On 4 June 1992, the Russian Supreme Soviet adopted a draft edict authorizing MAPO to independently carry out marketing of MiG-29 aircraft. Furthermore, during the exhibition an agreement was signed on the creation of a joint venture with a German firm to render assistance in the operation of the MiG-29's that are in the German inventory.

Sale of the MiG-29, like other military equipment, is being restricted for political reasons. Taiwan's deputy minister of foreign affairs, studying the possibility of purchasing 90 MiG-29 aircraft for Taiwan's Air Force, recently visited Russia but received a refusal from Russia along with several Western countries to which Taiwan had turned with a similar request for the sale of modern aircraft.

Demonstration of the aircraft at various air shows by the "Swift" aerobatics team, recently formed at Kubinka Airfield and flying MiG-29 aircraft, is helping to market it. Many foreign pilots and experts, to whom the opportunity was presented to complete familiarization flights in the aircraft, have noted the aircraft's high specifications.

#### The MiG-25 Aircraft

The MiG-25RB reconnaissance-bomber aircraft, displayed on the ramp and in the air, is designed to conduct imaging and radar reconnaissance from high altitudes and conduct bombing strikes against fixed targets.

Work on the development of this aircraft began in 1958 when the OKB imeni A.I. Mikoyan began to study a high-altitude reconnaissance aircraft that was capable of executing missions with which the Lockheed U-2 and Martin/General Dynamics RB-57F aircraft were tasked in the United States. During the course of the work, a multimission aircraft was developed that was capable of carrying out various combat missions.

MiG-25 strike reconnaissance aircraft were employed in combat operations in the Middle East in 1982 and in the Iran-Iraq conflict, practically without combat losses (several aircraft were lost as a result of accidents or unskilled tactical utilization when missions that were not characteristic to the aircraft were assigned to them). Iraqi MiG-25 aircraft were successfully employed to destroy Iranian oil terminals (relatively

small targets), conducting bombing using INS from high altitudes at supersonic speed. During the Persian Gulf War, the Iraqi side practically did not utilize MiG-25 reconnaissance-strike aircraft.

The following modifications of the reconnaissance and reconnaissance-strike aircraft were developed: The MiG-25R (1966)—high-altitude, high-speed, reconnaissance aircraft; the MiG-25RBK (1972-1980), the MiG-25RBS (1972-1977), the MiG-25RBV (1978), the MiG-25RBT (1978), the MiG-25RBF (a reconfigured MiG-25RBK, 1981), the MiG-25RBSh (a reconfigured MiG-25RBS, 1981)—strike reconnaissance aircraft; the MiG-25BM (1982-1985)—a strike-defense suppression aircraft; and the MiG-25RU (1972)—a trainer aircraft.

High temperatures caused by kinetic heating of the structure required the involvement of many enterprises during the development of the aircraft, ensuring the development of special steels, heat-resistant glass, seals, rubbers, sealants, glues, and other promising design materials. Approximately 80% of the aircraft structure was made from steel, 8% from titanium alloys, 11% from aluminum alloys and, 1% from other materials.

Aircraft equipment is linked into a single system and includes an INS (the first in series-production tactical strike aircraft), an onboard digital computer, a Doppler slip and drift sensor (DISS), a Peleng bombing system that conducts the automatic release of bombs at assigned coordinates, an ASU-155 automated command and control system, and an SPS-141 electronic warfare system (MiG-25RBT). Reconnaissance equipment consists of an A-72 and A-10-10 aerial cameras (on the MiG-25R and MiG-25RB), and a Virazh SRS-4A and SRS-4B (MiG-25R and MiG-25RB), the SRS-9 (MiG-25RB), and the Kub MiG-25RBK) and Sablya (MiG-25RBS) side-looking radar systems (RLSBO).

MiG-25 reconnaissance-bomber aircraft weaponry consists of up to 4,000 kg of 500 kg bombs on four underwing external suspension points that can be employed at high supersonic speeds. The MiG-25BM defense suppression aircraft is equipped with four Kh-58 guided missiles (launch range of more than 40 km).

The reconnaissance-bomber aircraft was series produced in 1969-1984 at the aircraft plant at Nizhny Novgorod (Gorkiy). Series production of the aircraft was terminated in 1984 and reconfiguration of previously built aircraft into the MiG-25BM variant continued until 1985.

At the present time, the OKB has developed variants for the modernization of the MiG-25 aircraft that ensure the increase of its combat effectiveness due to the introduction of aerial refueling, new guided weaponry, avionics, and electronic warfare systems.

#### Specifications of the MiG-25RB Aircraft

Wing span, m	13.42
Aircraft length, m	21.55
Wing area, m <sup>2</sup>	62.40
Engines	R-15B-300 TRDF (turbojet engine with afterburner) (2 x 112.5 kN)
Maximum take-off weight, kg	41,200
Normal take-off weight, kg	37,000
Weight of fuel in internal tanks, kg	15,245
Maximum speed, kph	3,000 (Mach 2.83)
Service ceiling, m	23,000
Flight range at supersonic speed without external fuel tanks, km	1,635
Flight range at subsonic speed without external fuel tanks, km	1,865
Flight range at supersonic speed with external fuel tanks (1 x 5 300 l), km	2,130
Flight range at subsonic speed with external fuel tanks (1 x 5 300 l), km	2,400
Time to climb to an altitude of 19,000 m, minutes	6.6
Time to climb to an altitude of 19,000 m with 2,000 kg of bombs, minutes	8.2
Maximum operational G-load	3.8

#### The MiG-31 Interceptor Aircraft

The MiG-31 aircraft, developed based upon the MiG-25P fighter-interceptor aircraft, is designed for use in the PVO system and is capable of carrying out prolonged patrols and conducting combat with all classes of aerodynamic targets (including small cruise missiles, helicopters, and Lockheed SR-71 class high-altitude, high-speed aircraft) at any time of day, in complex weather conditions, and under intense conduct of electronic warfare.

In 1972 the OKB began work on an improved variant of the MiG-25 fighter aircraft that received the designation Ye-155MP (Item 83, MiG-25MP) and was designed to combat both high-altitude and also low-flying targets with a reduced RCS. The first flight of this aircraft took place on 16 September 1975 (test pilot A. Fedotov). In contrast to the initial aircraft, the crew of the new fighter-interceptor consisted of two men and the Zaslon radar gunsight was included as part of the avionics. Zaslon had been developed since the beginning of the 1960's for the Tu-148 long-range variable geometry wing interceptor which had been proposed to replace the Tu-128 aircraft.

Series production of the MiG-31 fighter aircraft began in 1979 at an aircraft plant in Nizhniy Novgorod (Gorkiy), the first aviation unit based at Pravdinsk was equipped with the new fighter aircraft in 1980, and the MiG-31

completed state testing in December 1981. In June 1991 the aircraft was demonstrated for the first time at the Paris Air Show and was exhibited at the International Air Show in Dubai in the autumn of 1991.

Structurally, the MiG-31 fighter aircraft is close to the MiG-25. Its airframe is 50% manufactured from stainless steel, 16% from titanium, 33% from aluminum alloys, and 1% from other construction materials. There are small extensions in the root section of the wing. Onboard equipment permits the utilization of the MiG-31 fighter-interceptor aircraft autonomously, as part of a group of identical aircraft or as an aircraft-leader for command and control of fighter operations that have less improved avionics (the MiG-23, MiG-25, MiG-29, Su-27, or Su-15).

The aircraft is equipped with the Zaslon SBI-16 pulse-Doppler radar with a high-power phased-array antenna (the diameter of the antenna, installed fixed, is 1.1 meters). The MiG-31 is the first (and, so far, the only) series production fighter aircraft in the world with a phased-array antenna that has only electronic scanning (an antenna of this type has been developed for the fifth generation F-22 aircraft and the Rafale C).

Maximum detection range of a target with an RCS of 16 m<sup>2</sup> is 200 km, tracking range of an AWACS aircraft class target—120 km, fighter class target—90 km in the forward hemisphere and 120 and 70 km, respectively, in the rear hemisphere. The radar's horizontal search sector is 140° (in certain modes—240°, that is, it provides surveillance both in the forward and in the rear hemispheres), and the vertical search sector is +70/-60°.

The radar permits detection and destruction of aircraft (including low-observables), helicopters, and cruise missiles in the upper hemisphere and in the background of the surface, carries out simultaneous tracking of up to 10 targets, and simultaneous guidance of guided missiles to four targets. In contrast to the American Grumman F-14 Tomcat fighter aircraft which is capable of track-while-scan and simultaneously guiding AIM-54 Phoenix guided missiles to various targets in a relatively narrow sector (+/-20°), the MiG-31 aircraft radar can operate in these modes practically in the entire search sector.

The MiG-31 fighter is equipped with infrared radar on an extendible base permitting it to carry out a search and employ weapons without revealing its location, and also to operate under conditions of intensive electronic jamming.

A group of four MiG-31 aircraft is capable of controlling airspace 800-900 km along the front. An APD-518 digital encrypted communications system supports the exchange of radar information in a group of four MiG-31 aircraft at a distance of up to 200 km from each other and guidance to a target of a group of fighters that have less sophisticated avionics. An RK-RLDN digital encrypted data exchange link supports coordination with ground-based command posts. Utilization of the APD-518 system ensures stealthy attack of a target by a MiG-31 aircraft while the target is being tracked by

another fighter aircraft located a safe distance from enemy aircraft and relaying radar information to the attacking aircraft.

A large-format tactical situation display has been installed in the operator's cockpit and the pilot's cockpit is equipped with a PPI- 70V color head-up display developed by Voskhod MPKB, which has no series-produced foreign equals at the present time. Navigational equipment includes a Tropik radar-navigation system (Loran, accuracy of the determination of coordinates is 0.13-1.3 km at a distance of 2,000 km) and a Marshrut (Omega, accuracy of the determination of coordinates is 1.8-3.6 km at a distance of 2,000-10,000 km). It provides the capability to employ the aircraft in the Arctic TVD [theater of military operations].

It has an aerial refueling system with a retractable probe. The aircraft is equipped with a bogie undercarriage that permits operation from dirt runways (which is especially important during operation of the aircraft in unconquered areas of Siberia where there is no developed runway network). The fighter is equipped with D-30F6 turbojet bypass engines with afterburner (2 x 9 270/155 kN, dry weight 2,420 kg), development of which began in 1972.

The MiG-31 aircraft's weaponry includes R-33 long-range guided missiles (launch range—120 km) located on four external semirecessed suspension points under the fuselage, R-40T medium-range guided missiles with an IR homing system, and the R-60, R-60M, or R-73 close-range guided missiles on four underwing suspension points. A six-barrel GSh-23-6 cannon (23 mm, 260 rounds, rate of fire 8,000 rounds per minute, weight of round 200 grams, muzzle velocity 700 meters per second) has been installed under the fuselage, the firing

port of which is covered by a special hatch in the nonoperating position which improves aerodynamics and reduces the aircraft's RCS.

The MiG-31M fighter-interceptor was demonstrated at the aircraft demonstration for the CIS countries leaders at Machulishchi (Belarus) in the winter of 1992. In contrast to the initial variant, a more powerful radar has been installed on the modernized fighter, weaponry has been increased and consists of six long-range guided missiles located on semirecessed suspension points under the fuselage and the highly maneuverable RVV-AE medium-range guided missiles on underwing suspension points. The aircraft wing has increased area extensions, the dimensions of the fuselage fairing have been increased, and the pilot cockpit's forward windshield has been manufactured in one piece.

The U.S. Navy's F-14 Tomcat carrier-based interceptor, designed to provide air defense for aircraft carriers, is the closest fighter to the MiG-31 by mission. The MiG-31 aircraft significantly exceeds the American aircraft in maximum speed and ceiling, and has approximately identical ferry range with it and comparable onboard radar capabilities. Until 1990 the Harris AN/ASW-27B communications system was utilized on the F-14A fighter aircraft, providing an automated exchange of information only between fighter aircraft and shipborne command posts or E-2C Hawkeye AWACS aircraft which performed the role of relays and could transmit information, received by the F-14 fighter's onboard radar, to other fighters that were part of the group. The AN/ASW-27C digital communications system which provides exchange of information in the automatic mode between four aircraft began to be installed on F-14 aircraft only at the end of 1991.

Specifications of the MiG-31, F-14A, and F-14D Fighter Aircraft

Type of Aircraft	MIГ-31	F-14A	F-14D
Year of First Flight	1975	1970	1987
Wing span, m	13.46	11.65/19.34	11.65/19.34
Aircraft length, m	22.69	19.10	19.10
Aircraft height, m	5.15	4.88	4.88
Wing area, m <sup>2</sup>	61.60	52.49	52.49
Normal take-off weight, kg	41,000	31,660	32,100
Maximum take-off weight, kg	46,200	30,700 <sup>a</sup>	33,720 <sup>aa</sup>
Weight of fuel in internal tanks, kg	16,350	7,350	7,350
Weight of fuel in external fuel tanks, kg	4,000	1,720	1,720
Type of engines	D-30F6	TF30-414	F110-400
Maximum thrust, kN	2 x 155	2 x 95	2 x 123
Thrust-to-weight ratio at normal take-off weight, kgs/kg	0.76	0.62	0.73
Unit wing loading at normal take-off weight, kg/m <sup>2</sup>	666	603	642
Maximum speed, kph	3,000	2,120	2,430
Maximum speed at sea level, kph	1,500	1,400	1,400
Maximum cruising speed, kph	2,400	1,020	1,020

Specifications of the MiG-31, F-14A, and F-14D Fighter Aircraft (Continued)

Type of Aircraft	MIK-31	F-14A	F-14D
Year of First Flight	1975	1970	1987
Service ceiling, m	20,600	15,200	15,200
Service flight range without external fuel tanks, km	2,500		
Ferry range with external fuel tanks	3,300	3,220	3,220
Line of interception, km:			
At supersonic speed	720	500	600
At subsonic speed without external fuel tanks	1,200		
At subsonic speed with external fuel tanks	1,400	1,400	1,500
At subsonic speed with one aerial refueling	2,000		
Time to climb to 10,000 m, minutes	7.9		
Flight duration, hours:			
Without aerial refueling	3.6		
With one aerial refueling	6-7		
Landing speed, kph	280	248	248
Take-off run, m	1,200	430	
Landing run, m	800	890	
Maximum operational G-load	5.0	6.5	7.5
Maximum onboard radar target detection range, km/target RCS, m <sup>2</sup>		200/16	210/5
* With four Phoenix guided missiles			
** With six Phoenix guided missiles			
*** In the entire range of the radar's search angles			
**** In a sector of +20°			

According to foreign data, there were more than 200 MiG-31 fighter-interceptors in the inventory of the CIS countries' PVO troops at the beginning of 1992 and another 24 aircraft of this type were delivered to China.

### The MiG-23 Aircraft

Demonstrated at the exhibition, the MiG-23MLD aircraft is the latest modification of the MiG-23 fighter aircraft family and that was one of the Soviet Air Force's primary frontal aviation fighter aircraft for a long time. Work on the development of the new generation aircraft to replace the MiG-21 frontal aviation fighter aircraft began at the OKB imeni A.I. Mikoyan in 1961. The MiG-23 was developed as a comparatively cheap aircraft capable of being effectively employed in local conflicts, for air defense of individual major targets, and also supplied for export.

A great deal of work, conducted by the OKB in cooperation with TsAGI, preceded the development of the MiG-23MLD. The assigned task was to substantially improve the aircraft's maneuverability and handling at high angles of attack since success in a dogfight depends to a significant degree on mastery of those regimes. Several configurations of the new aircraft were studied, differentiated by the dimensions and shape of the wing glove leading-edge assembly and the shape of the vertical

tail. The selected configuration provided a substantial improvement of maneuverability with minimal modification of the airframe.

A second "tooth" extension was made on the MiG-23MLD aircraft's wing root, a vortex generator shaped like a small (365 mm long) plate with sharp edges was installed on the PVD [pitot tube], and it became possible to set the computer-controlled deflecting wing leading edge slats to the optimal position depending on the flight regime.

The fighter is equipped with an improved radar that is capable of simultaneously detecting and tracking several airborne targets and an improved automated command and control system from the ground in which a jam-proof data transmission link is utilized. An automated system prevents engine stall during missile launch and firing from the cannon. A close-range mode has been introduced in the radar and the pilot is equipped with a helmet-mounted target designation system.

Besides the development of ground-based aircraft, work was conducted on the MiG-23A carrier-based modification designed for deployment on a nuclear aircraft-carrying ship with catapult take-off, developed under the codename Orel since the beginning of the 1970's. However, cessation of work on Project Orel in 1977 resulted in the termination of work on the MiG-23A fighter aircraft. Later, one of the MiG-23M series aircraft was

reconfigured into a flying laboratory and used at the LII imeni Gromov to develop landing techniques on ship decks and also to develop the fundamental elements of a ship aircraft technical system (ATSK) including an optical landing system, various radiotechnical systems, etc. The aircraft was equipped with an arresting hook, which entailed changing the shape and increasing the area of the ventral fin. A movie camera that recorded the pilot's face during take-off and landing with high G-loads was installed in the cockpit instead of a collimating gunsight. In 1980 a scientific-research complex with a ski jump, arresting gear, and a prototype catapult, where flight tests of the MiG-23 flying laboratory were also conducted, was put into operation in the area of Saki (the Crimea). Materials obtained during tests were utilized in the work on the MiG-29K and Su-27K aircraft designed for the Admiral Kuznetsov and Varyag heavy aircraft-carrying ships with ski jump take-off.

Developed in 1973, the export variant of the MiG-23MS fighter with simplified avionics (specifically, the Sapfir-21 radar) gained wide sales because it had high I.T.K. [flight technical specifications] with a relatively low cost. So, in 1980 prices, one MiG-23MS sold for \$3.6-6.6 million at a time when IAI's [Israeli Aircraft Industries] Kfir C.2 aircraft, which lagged behind the MiG-23's combat capabilities, cost \$4.5 million in 1978 prices, the Mirage III—\$6.5-7.5 million (1983 prices), the F-16A—\$14 million (1980 prices), and they proposed selling the Northrop F-20, which was considered to be a cheap fighter, to foreign purchasers for \$15 million (1985 prices).

By 1992, the MiG-23 was in the inventory of the air forces of Algeria (66 MiG-23MS, BN, and UB), Angola (80 MiG-23MF, BN, and UB), Bulgaria (48 MiG-23MF, BN, and UB), Cuba (40 MiG-23MS and BN), Czechoslovakia (80 MiG-23ML, BN, and UB), Egypt (16 MiG-23MS and BN obtained in 1974 and partially transferred to the United States and China), Ethiopia (45 MiG-23BN), Hungary (25 MiG-23MF and UB), India (125 MiG-23MF, delivered in 1982 to counteract F-16 deliveries to Pakistan, MiG-23BN and MiG-23UB and, furthermore, the MiG-27L Bahadur aircraft are being series produced in India), Iraq (MiG-23MS, MF, BN, and UB, the precise number after the termination of the war is not known), Libya (200 MiG-23MS, BN, and UB), the DPRK (60 MiG-23ML and UB), Poland (100 MiG-23MF and UB), South Yemen (25), Syria (175 MiG-23MS, MF, MLD, and UB), and Vietnam (30). Furthermore, 110 MiG-23MF, ML, BN, and UB aircraft passed into the possession of the FRG after the unification of the two Germanys. The PRC has two to three MiG-23's that were obtained from Egypt (the MiG aircraft were painstakingly studied by Chinese experts and many of their design solutions were utilized during the development of the J-8-II aircraft). Several MiG-23MS and MiG-23BN aircraft were transferred to the United States by the Egyptian Government at the end of the 1970's. The famous American General Robert S. Bond died in one of these aircraft (the flight was conducted within the framework of the Stealth Program: The U.S. Air Force was interested in how low-observable aircraft would be detected by Soviet

fighter aircraft radars). In 1991 the Americans obtained several MiG-23ML aircraft from the FRG.

The first major combat clash with the participation of MiG-23's occurred on 19 September 1979 when Syrian MiG-23MS's attacked an Israeli RF-4 Phantom II over Lebanon; however, they did not achieve success. The Israeli invasion into Lebanon began in June 1982. On 10 June, 350 aircraft from both sides participated in a dogfight over the Bekaa River Valley. The Syrians lost 22 fighters (four MiG-23MF, eight MiG-23MS, and 10 MiG-21BIS). Israeli aircraft losses totaled 10 aircraft. On the whole, from 6 through 11 June, when a cease-fire agreement was concluded, the Syrian Air Force shot down 23 aircraft and lost 47 aircraft in dogfights.

At the end of 1982 a shipment of 50 MiG-23MLD's arrived in Syria which promoted a change of the qualitative correlation of forces in the air in favor of the Syrians. In December 1982, air engagements between Syrian and Israeli aircraft resumed, but this time success was with the Syrians: Their MiG-23MLD's shot down three Israeli F-15 Eagle and one F-4 Phantom II fighter aircraft.

Angola was another theater of military operations in which the MiG-23 was widely employed. In 1985, 50 MiG-23MF aircraft piloted by Cuban pilots were sent to that country. The aircraft were immediately rushed to the south of the country where they became involved in combat operations. The first MiG-23 aircraft was shot down by anti-aircraft fire at the end of 1985 (according to other information, Republic of South Africa [RSA] Air Force aircraft shot it down). The Dassault-Breguet Mirage F1C and Mirage III fighter aircraft in the RSA Air Force inventory were the primary enemy in the air. According to a Western press report, several aircraft of these types were destroyed by Angolan and Cuban MiG-23 fighters armed with R-60 guided missiles. On the whole, the Angolan-Cuban Air Forces won and maintained supremacy in the air over the southern areas of the country.

MiG-23's of various modifications were widely utilized by Iraq in the war with Iran. The Iraqi Air Force had MiG-23MF and MiG-23MS fighters and MiG-23BN fighter-bombers at its disposal. Having aircraft of both Soviet and also Western manufacture (specifically, Mirage F-1EQ fighters), Iraq widely practiced the modernization of its aircraft fleet permitting the aircraft to utilize "alien" weaponry. So, the Mirage F-1EQ fighters were armed with Soviet Kh-29L air-to-surface missiles with a laser guidance system and MiG-23MF's were equipped with Magic R.550 close-range air-to-air guided missiles. MiG-23MF's were utilized for air superiority and for interception of Iranian F-14A Tomcat aircraft (Iran utilized these fighter-interceptors, which have a long flight range, primarily as bombers and reconnaissance aircraft).

The 1991 Persian Gulf War was the last war in which MiG-23's participated. By the beginning of combat operations, Iraq had 90 MiG-23MF and MiG-23BN aircraft, however Iraqi aircraft were utilized extremely passively and air engagements were solitary in nature. Altogether during the course of the war, U.S. fighters (according to Western data) shot down six MiG-23 aircraft (all by F-15 fighters).

There were no published reports in the Western press of American aircraft losses in engagements with MiG-23's, however, according to certain sources, MiG-23MF's shot down at least one F-16 utilizing R-23 guided missiles.

MiG-23 aircraft can be modernized by equipping them with more modern weapons systems and avionics, which will permit them to maintain the combat capabilities of this fighter aircraft close to the level of foreign fourth generation fighter aircraft for a prolonged period of time.

Comparative Specifications of Aircraft

Type of Aircraft	MiG-23MLD	F-16C	Mirage 2000C
Wing span, m	7.8/14.0	9.5	9.1
Aircraft length, m	16.7	14.5	14.4
Wing area, m <sup>2</sup>	34.2/35.5/ 37.7	27.9	41.0
Normal take-off weight, kg	14,800	12,800	11,600
Maximum take-off weight, kg	17,800	17,000	17,000
Type of engine	-25F-300	F100-200	M53-P2
Maximum afterburner thrust, kN	1 x 130	1 x 108	1 x 97
Thrust-to-weight ratio	0.88	0.84	0.84
Unit wing loading (at normal take-off weight), kg/m <sup>2</sup>	417 <sup>aa</sup>	459	283
Maximum speed, kph	2,500	2,170	2,340
Maximum speed at sea level, kph	1,400	1,470	1,480
Service ceiling, m	18,300	15,200	18,000
Maximum rate of climb, meters per second	240	250	250
Operational range (without external fuel tanks), km	1,900	1,900	1,480
Ferry range, km	2,820	3,890	3,340
Total amount of fuel in external fuel tanks, liters	2,400	4,060	4,700
<b>Weaponry:</b>			
Cannon (number of barrels x caliber, mm)	2 x 23	6 x 20	2 x 30
Medium-range guided missiles (number X type)	2 x R-23	None <sup>aaa</sup>	2 x S.530
Short-range guided missiles	4 x R-60	4 x AIM-9	2 x R.550
Bomb payload, kg	2,000	5,400	6,300

<sup>a</sup> Area with sweep angle of 16, 45, and 72°.

<sup>aa</sup> With a combat sweep angle of 45°.

<sup>aaa</sup> They propose additional arming with AIM-120 ASRAAM guided missiles.

## The MiG-27K Fighter-Bomber

Demonstrated on the ramp, the MiG-27K fighter-bomber is a development of the MiG-23 frontal aviation fighter aircraft. In 1969 the OKB imeni A.I. Mikoyan prepared a design of a light strike aircraft based upon the MiG-23S fighter aircraft. The new aircraft completed its first flight on 20 August 1970 (test pilot P.M. Ostapenko). In contrast to the MiG-23S fighter aircraft, the fighter-bomber, which received the designation MiG-23B, had a modernized fuselage nose section that provides an improved field of view in the ahead-below direction and was designed to conduct strikes against fixed ground-based targets in the enemy rear area and also ground attack operations using cannon and unguided rockets during the day.

The MiG-23B was equipped with a Fon laser rangefinder, a Sokol-23S gunsight system optimized for operations against ground-based targets from low altitudes that provides a dual standard error of 2.8% of range, and a KN-23 navigation system with an analog computer capable of "remembering" the coordinates of three route turning points (PPM) and four airfields at which the aircraft could complete a landing after a combat mission. The MiG-23B was equipped with a 23B automated command and control system (SAU) and a RV-5R radio altimeter.

The AL-21F-300 turbojet engine with afterburner (1 x 8,000/112 kN) was employed on the fighter-bomber. The increase of the maximum take-off weight in contrast to the MiG-23S and the need to operate the troop direct support aircraft from ground airstrips resulted in the increase of the size of the wheels and the employment of reduced-pressure tires.

Bomb weaponry included up to 18 50-100 kg bombs or eight 500 kg bombs on underwing and ventral hard points. Another weaponry variation includes four UB-32A unguided rocket pods with 32 S-5 57 mm rockets or four more modern B-8M pods with 20 S-8 80 mm unguided rockets. Furthermore, Kh-23 guided missiles can be hung under the wing that are guided by a beam using Delta guidance equipment mounted on the left wing pylon. R-2S close-range guided missiles with an IR homing system are employed for self-defense. Cannon weaponry, like on the MiG-23S, consisted of a GSh-23L twin-barreled cannon with a firing rate of approximately 3,000 rounds per minute.

Series production of the aircraft was begun in 1971, however, after the manufacture of a small series at the Znamya truda MMZ [manufacturing plant], the production of a new modification fighter-bomber—the MiG-23BN ("32-23") was begun in which a wing similar to the MiG-23M fighter wing, the R-29B-300 engine (1 x 8,000/115 kN), and also the improved Sokol-23N navigation-bomb system were utilized. It had two additional external hard points in the tail section of the fuselage and reinforced armor of the sides of the cockpit. The MiG-23BN was built in a large series for deliveries for export (certain aircraft were reconfigured from MiG-23M

fighters directly at Air Force repair facilities). The commonality of the design of the MiG-23M and the MiG-23BN totaled 80%.

Later, the MiG-23BM ("32-25", 1973) and the MiG-23BK ("32-26", 1974) fighter bombers were developed, which are distinguished by their avionics (specifically, the PrNK-23 that was installed on the MiG-23BM had a digital computer instead of the analog computer that was installed on earlier modifications of the aircraft).

Reduction of the requirement for the speed characteristic of the fighter-bomber that is designed primarily for operations at low altitudes with transonic speed permitted them to reject the use of a variable air intake on the next modification of the strike aircraft, which was given the designation MiG-27, which simplified and facilitated the design of the airframe.

The MiG-27 aircraft, built in 1973, was designed for operations against fixed and mobile ground-based targets. Bombing was ensured even when the target was not visible, including in difficult regimes, when weapons of two different types are used during a single run. The capability for a repeat automatic run over the target was provided for.

Besides installing armored plates along the sides of the cockpit, the MiG-27 aircraft's combat survivability was ensured by pressurizing the fuel tanks with a neutral gas.

V.Ye. Menitskiy completed the first flight in the new aircraft and A.V. Fedotov, B.A. Orlov, A.G. Fastovets, T.O. Aubakirov, V.V. Ryndin, and other OKB and LII test pilots participated in the flight tests. Series production of the MiG-27 began at Irkutsk Aircraft Plant in 1973 and continued until 1977, a total of 560 aircraft of this type were produced.

The MiG-27 fighter-bomber's weaponry was supplemented with the Kh-25MR guided missile with a radio command guidance system. Cannon weaponry was substantially increased and included the six-barrel GSh-30-6 30 mm cannon. The aircraft was equipped with an R-29F-300 turbojet engine with afterburner (8,000/115 kN).

The avionics included a PrNK-23 with a digital processor (the system is capable of calculating the aircraft trajectory, artillery rounds fired from the onboard cannon, missiles, and bombs), a Fon laser rangefinder, a KN-23 navigation computer (capable of "keeping in memory" six route turning points and four airfields and providing a dual standard error under autonomous navigation of 1.0%), 6S RSNB [radio navigation system], an NI-50BM Doppler navigation radar, an SAU23BI, an RI-65 speech accident warning system that issues 16 different information reports and commands to the pilot in emergency situations that are recorded on a magnetic tape using a female voice (it has been established that a pleasant female voice reaches a pilot's consciousness more rapidly than male speech in a critical situation).

The MiG-27K modification that was developed in 1975 was a further development of the MiG-27 (it is this modification that was demonstrated at "Moseroshow-92").

The aircraft is equipped with significantly improved avionics, specifically, the Kayra PrNK-23K. The optical head of the laser gunsight-rangefinder can be rotated in a limited sector ( $\pm 40^\circ$  in azimuth,  $130^\circ$  in elevation), ensuring target tracking during aircraft maneuvers. While tracking an unseen target, the coordinates of which have been entered into the onboard computer, illumination was carried out in a programmed mode when the laser beam, which is constantly holding on the target, automatically adjusts to a certain angle depending on the speed of the aircraft's movement. A television camera was utilized to track the target and a monochrome television monitor was installed in the cockpit. The aircraft was equipped with an automated defensive system which included IR flare dispensers and chaff.

The MiG-27K's automated weapons control system provides automatic release of bombs, both individually and also in a series, and indication of the release of munitions and their presence onboard the aircraft. The MiG-27K became one of the first aircraft armed with improved precision-guided missiles with television and laser guidance systems, and also with guided bombs. The employment of missiles with laser guidance system in the programmed adjustable tracking mode (PKS) has been provided for. The MiG-27K is equipped with Kh-25MP missiles to combat enemy radars.

Other weaponry that is located on the aircraft's external hard points includes R-60 close-range missiles, S-24 and S-24B (240 mm) unguided rockets, UB-32A or UB-16 57 mm rocket pods, B-8M1 S-8 80 mm rocket pods, up to 22 50 kg or 100 kg bombs, up to nine 250 kg bombs, or up to eight 500 kg bombs. RBK-250 disposable bomb canisters, BetAB-250 and BetAB-500 concrete-piercing munitions with a jet booster, BRAB-200DS, BRAB-220, BRAB-500, and BRAB-1000 armor-piercing bombs, and napalm tanks can be hung under the aircraft. Small caliber bombs are placed on MBD3-U6-68 multifixture storage racks.

The MiG-27K aircraft that was demonstrated at the exhibition was equipped with a Kh-31 antiradiation guided missile.

The MiG-27K fighter-bomber was equipped with a head-up display (HUD), the SAU 23BI, a Korall-N close navigation radio system, an AO-31 radio altimeter, and on board electronic warfare systems. The navigation system ensures a dual standard error of less than 1.0%.

The aircraft was in series production from 1977-1982 at Irkutsk Aircraft Plant (200 aircraft were produced).

A Klen laser rangefinder-target designator was installed in the nose section in a simpler modification of the

MiG-27M ("32-29") aircraft that was produced in 1978-1983 at Irkutsk Aircraft Plant (150 aircraft were manufactured). The aircraft were equipped with a KN-23S navigation system, a Klstron system, an improved AO-31 radio altimeter, a television display in the cockpit which, however, can operate only from a television guidance system of a guided missile or bomb because there is no onboard television camera on the aircraft. There is also no HUD. In contrast to MiG-27's of previous modifications, the aerodynamics of the ventral cannon mount have been improved (the fairing of the breech portion of the gun has been increased and powder gas deflector plates have been installed).

The aspiration to approximate the combat capabilities of previously built MiG-27's to the characteristics of the MiG-27M resulted in the development of the MiG-27D aircraft ("32-27")—a previously produced MiG-27 that has been reequipped with the MiG-27M aircraft's avionics. Reequipping the fighter-bombers began in 1982 at the aircraft plant at Ulan-Ude and was completed in 1985. A total of approximately 500 MiG-27's were modernized.

The MiG-27D could be equipped with a canister with an aerial camera and utilized as a frontal aviation reconnaissance aircraft.

The MiG-27ML ("32-29L") that was manufactured in 1982 and has simplified avionics is the export variant of the MiG-27M aircraft. The aircraft was developed based on India's order and is being produced by the NAL firm at the aircraft plant at Nasik under the designation "Bahadur" ("Valiant"). A small series of MiG-27ML's and parts kits for the first shipment of aircraft assembled in India was manufactured at the plant in Irkutsk. Assembly of the first Indian MiG-27 manufactured from parts supplied by the USSR was completed on 11 January 1986 and manufacture of Indian "Bahadur" fighter-bombers began in 1988. They propose manufacturing a total of 165 aircraft of this type in India, which should compose the foundation of Indian Air Force strike aviation in the 1990's. They propose reequipping

the "Bahadur" aircraft with Western avionics developed for the Indian variant of the Jaguar aircraft that includes the Smith Industries Darim navigation/attack system and also the Thomson Agave radar.

The Syrian Air Force utilized MiG-23BN fighter-bombers to inflict massive strikes against targets in the depth of the Israeli combat formations (several aircraft were lost from enemy ZSU [self-propelled antiaircraft artillery mounts] fire as a result of not totally successful planning and organization of air operations) during the course of combat operations between Israel and Syria in the Bekaa River Valley during the summer of 1982.

MiG-23BN's, piloted by Cuban pilots, were successfully employed in Angola for strikes against ground-based targets, specifically, combat positions and lines of communication of RSA and UNITA [National Union for the Total Independence of Angola] troops, however, two aircraft of this type were destroyed by enemy air defense ground-based weapons fire (specifically, by Chinese NI-5A PZRK [portable antiaircraft missile system]—copies of the Soviet Strela-2 portable antiaircraft missile system) in 1987.

During the course of the Iran-Iraq War, Iraqi MiG-27BN's were used to conduct strikes against oil terminals and naval surface targets in the Persian Gulf and also against ground-based targets in the theater of military operations. The aircraft's combat capabilities were increased even more after equipping it with a nonretractable aerial refueling probe similar to the one utilized on the Mirage F-1EQ and also with a pod with the French-made ATLIS optical-electronic tracking and target designation system which permitted an increase in the launch range of the Kh-29L guided missile from 8-10 km (with a Soviet-made laser illumination system) to 14 km.

In contrast to the MiG-23BN, the MiG-27 has hardly been utilized in combat operations, with the exception of Afghanistan (based on the experience of this war, many MiG-27's and MiG-23's were equipped with additional IR flare pods that are located on the fuselage and, based upon their shape, resemble stall fences).

Relative Specifications of the Combat Effectiveness of the MiG-23BN and MiG-27 Aircraft

Type of aircraft	MiG-23BN	MiG-27	MiG-27K	MiG-27M	MiG-27ML	MiG-27D
Relative losses during one combat sortie	1.00	0.50	0.36	0.36	0.40	0.36
Required detail to carry out a typical combat mission	1.00	0.70	0.40	0.50	0.50	0.50

#### The MiG-21 Fighter Aircraft

At the present time, the MiG-21 aircraft is the most widespread fighter aircraft in the world. It was series produced for approximately 28 years (from 1959 through 1986) at the Znamya truda MMZ, Gorkiy Aircraft Plant and also at the aircraft plant at Tbilisi. MiG-21 aircraft of various modifications were supplied to the air forces of the USSR, Algeria, Angola, Bangladesh, Bulgaria, Burkina Faso, Cuba, Czechoslovakia,

Germany, Egypt, Ethiopia, Finland, Guinea, Hungary, India, Iraq, Yugoslavia, Laos, Libya, Madagascar, Mongolia, Nigeria, the DPRK, Vietnam, Poland, Romania, Somalia, Sudan, Syria, Uganda, and Zambia. The MiG-21 was built in India and China based on a Soviet license (the Chinese variant of the MiG-21F-13 aircraft, the J-7, is in series production up to the present time).

The following primary modifications of the MiG-21 fighter aircraft have been developed: the MiG-21F (first

flight—1958) and the MiG-21F-13 (1959)—frontal aviation fighters designed for use during the day; the MiG-21PF (1962), the MiG-21FL (1964), the MiG-21PFM (1964), the MiG-21PFS (1964), the MiG-21S (1965), the MiG-21SM (1968), the MiG-21M (1968), the MiG-21MF (1970), the MiG-21MT (1971), the MiG-21SMT (1971), and the MiG-21bis (1972)—frontal aviation all-weather fighters equipped with a radar gun-sight; the MiG-21R (1965)—a frontal aviation reconnaissance aircraft; the MiG-21U (1960), the MiG-21US (1966), and the MiG-21UM (1971)—a trainer fighter aircraft; the MiG-21PD ("23-31", 1966)—an experimental aircraft with a combined power plant (an R-11F2-300 sustainer turbojet engine with afterburner and two RD-36-35 lift turbojet engines; and, the MiG-21I Analog (1968)—an experimental aircraft developed within the framework of the Tu-144 SPS program. A total of more than 20 modifications of the MiG-21 aircraft were developed.

Type of aircraft	MiG-21SM	MiG-21bis
Wing span, meters	7.15	7.15
Aircraft length (with the pitot tube probe), m	15.75	15.75
Fuselage length (without the pitot tube probe), m	12.29	12.29
Aircraft height, m	4.00	4.00
Wing area, m <sup>2</sup>	22.95	22.95
Type of engine	R-13-300	R-25-300
Maximum thrust, kgs	1 x 6,490	1 x 7,100 <sup>a</sup>
Take-off weight, kg	8,300	8,725 <sup>aa</sup>
Weight of fuel in internal tanks, kg	2,200	2,390
Maximum flight speed, kph	2,230	2,175
Maximum speed at sea level, kph	1,300	1,300
Operational range without external fuel tanks, km	1,050	1,120 <sup>aa</sup>
Ferry range with an external fuel tank (1 x 800 liters), km	1,420	1,470 <sup>aa</sup>
Service ceiling, m	17,500	17,500
Maximum rate of climb	204	225
Take-off run, m	800	830
Landing run with a braking parachute, m	550	550
Maximum operational G-load	8.5	8.5
Unit wing loading	360	380
Thrust-to-weight ratio	0.78	0.81

<sup>a</sup> It has an extraordinary operating regime under which at altitudes of 0-4,000 m at a speed that corresponds to Mach 1, the turbojet engine with afterburner can develop thrust of up to 9,900 kgs for three minutes.

<sup>aa</sup> With two R-3S guided missiles.

MiG-21 aircraft of various modifications have participated in combat operations in Vietnam, where they demonstrated greater effectiveness as an air superiority fighter

than the American McDonnell-Douglas F-4 Phantom II aircraft. MiG-21 fighter aircraft were utilized in the Arab-Israeli wars in 1967, 1973 and 1982, in the 1971 Indo-Pakistani conflict, in the Iran-Iraq War, and also in combat operations in Angola and Afghanistan.

The MiG-21SM aircraft displayed at the exhibition is being used as a flying test stand within the MiG-21 aircraft avionics and weaponry modernization program. Two R-27 medium-range missiles, the employment of which from the MiG-21 fighter is possible after reequipping the aircraft with the Kopye small multifunction onboard radar specially developed for modernizing an aircraft of this type, were installed on the external hard points of the demonstrated fighter.

The radar is capable of:

- detecting and tracking airborne targets in the automatic mode, including targets flying at low altitude over land or water, without revealing the fighter's location;
- supporting an attack based upon target designation and destruction of targets with missiles with antiradiation or IR seeker heads and also using a cannon;
- carrying out a high-speed vertical search and automatic lock-on of visually observed targets at close range using improved guided missiles that have heightened maneuvering characteristics; and,
- forming a scale map with high resolution, enlargement of scale, and "freezing" the image.

The possibility to connect to analog and digital equipment onboard the aircraft and also ease of control of operation has been provided for.

Kopye radar equipment includes an antenna, a transmitter, an analog processor, a power source, a signal processor, a pulse generator, a synchronizer, an onboard digital computer, a unit to link to the computer, an information transformation unit, a CRT display installed in the cockpit, a built-in monitoring panel, a control panel, a HUD to which radar information is also sent, and a liquid cooling system.

The radar has seven primary operating modes:

- detection and automatic tracking of airborne targets in free space and in the background of the earth (sea) with the transmission of target designation to missiles with TGS [television seekers] or RGS [radar seekers], and also aiming using unguided weapons (the cannon, unguided rockets, or bombs);
- tracking of several targets and attacking them using missiles in the surveillance mode;
- the rapid search—close-range mode;
- cartography of the earth's surface using an active beam (low resolution);

- cartography of the earth's surface using synthetic aperture (high resolution);
- enlargement of scale of the selected sector of the map; and,
- measurement of the coordinates of the target selected on the ground (sea).

Based upon its primary specifications, the Kopye radar corresponds to or somewhat outstrips the American Westinghouse AN/APG-68 radar that has been installed on the General Dynamics F-16C aircraft.

A new automated command and control system, an RD-33 turbojet bypass engine with afterburner that is used on the MiG-29 aircraft, and also a Kh-35 antiship guided missile that can be hung on the ventral pylon are other improvements that can be employed on the modernized MiG-21 aircraft.

Based on the assessments of OKB representatives, the modernized variant of the MiG-21 fighter, based upon its combat capabilities, approximates fourth generation fighters with significantly lower cost.

At the end of 1991 it was reported that the Government of India had decided to conduct large-scale work on modernization of MiG-21 aircraft—the primary fighters of the Indian Air Force (production of the MiG-21bis aircraft based upon a Soviet license was completed in India in 1988, approximately 200 aircraft were built)—as a result of delay in the work to develop the LCA (Light Combat Aircraft) multimission fighter being developed by India jointly with Dassault-Breguet.

It is proposed to install new avionics and a new engine and change the shape of the wing to provide the best maneuvering characteristics on the modernized Indian MiG-21 aircraft. The RD-33 turbojet bypass engine with afterburner (8,300 kgs) or the RB-199 Turbo-Union (7,680 kgs) is regarded as a new engine.

Furthermore, the Government of India plans to provide modernized MiG-21 fighters for export. Based on Indian demands, an improved variant of the MiG-21 fighter has been developed at the OKB imeni A.I. Mikoyan. In September 1991 the technical documentation for the new variant of the aircraft was submitted to the Indian side for review. In accordance with the draft, changes were made to the fighter's avionics and weapons system, as a result of which the aircraft's combat potential increased by a factor of 2.5 to three. The cost of modernization of the MiG-21 aircraft should total approximately 30% of the cost of the fighter. It is proposed to perform work on the program at Indian and Russian enterprises. In the words of OKB imeni A.I.

Mikoyan General Designer R.O. Belyakov, they intend to resolve the problem of spare parts for Indian Air Force MiG-21 fighters by supplying India with parts of aircraft of this type that have been removed from the Russian Air Force inventory.

Work on a similar program in Pakistan, India's primary potential enemy, where it is planned, jointly with the PRC, to reequip J-7P fighters (the Chinese variant of the MiG-21F-13 aircraft that was supplied to Pakistan) with an RD-33 or RB-199 turbojet bypass engine with afterburner is one of the reasons that prompted the Indian side to decide to modernize the MiG-21 fighters.

Preliminary negotiations were reported on the joint development of a wide range of avionics for modernization of variants of MiG-21 aircraft (specifically, the development of new cockpit equipment and a weapons control system were proposed) between the OKB imeni A.I. Mikoyan and the British firm GEC Avionics during the course of the exhibition's work.

GEC Avionics is already cooperating with China in the sphere of developing improved avionics for the MiG-21 (J-7) fighter.

**Continuation of the "MOSAEROSHOW-92" RUSSIAN AEROSPACE EXHIBITION survey will be in No 41.**

[No 41, 13 October 1992, pp 1-64]

[Text]

#### **ANTK imeni O.K. Antonov Aircraft**

The participation of the ANTK [Aircraft Scientific Technical Combine] imeni O.K. Antonov in "Mosaeroshow-92" was sufficiently modest. The An-124 Ruslan and the An-225 Mriya "heavyweights" were absent and, of the light transport aircraft, only the An-72P patrol aircraft, the An-26P forest fire fighting aircraft, and also the An-32 and An-32B were displayed on the ramp and in different locations.

The An-72P patrol service aircraft is distinguished from the primary variant by the installation of weaponry and a surveillance system. Weaponry includes two unguided rocket pods on underwing pylons and a GSh-24 twin-barrel gun located in the right fairing in front of the main landing gear. Four bombs, which can be dropped in flight when the ramp is retracted under the fuselage, are suspended in the cargo compartment over the cargo ramp. The OTV day surveillance television system, which provides a resolution of 10 meters at a distance of 3,000 meters, is located in a fairing in front of the left main landing gear and is covered by a hood in the nonoperating state. The aircraft demonstrated at "Mosaeroshow-92" had speckled camouflage paint.

## Specifications of the An-72P

Crew	3 men
Engines:	
Number and type	Two Progress ZMKB (Zaporozhye Machine-Building Design Bureau) Series 1A D-36
Bench thrust	2 x 6,300 kgs
Weights and payloads:	
Maximum take-off weight	32,000 kg
Maximum cargo capacity while accomplishing transport missions	5,000 kg
Combat payload	630 kg
Flight data:	
Maximum flight cruising speed	720 kilometers per hour (kph)
Patrolling speed	300-350 kph
Service ceiling	10,100 m
Patrolling altitude	500-1,000 m
Required runway length (concrete, dirt with a firmness of 0.8 MPa, 8 kgs/cm <sup>2</sup> )	1,400 m
Patrol duration with an emergency fuel reserve for one hour of flight	5.0-5.3 hours

The An-26P forest fire-fighting aircraft was developed based on the series-produced An-26 transport aircraft through the installation of two external discharge devices (tanks) with a control system. The minor design differences of the An-26P and the An-26 permit the fire-fighting An-26P to be rapidly reconfigured into the initial transport variant. The An-26P's flight and ground operations are completely identical with the transport aircraft and ensure the utilization of a wide network of dirt airfields. The An-26P aircraft can be utilized to accomplish the following missions:

- visual air surveillance of the fire condition of large tracts of forest;
- visual assessment of fire-stricken area in order to develop fire-fighting strategy;
- on-target drop-zone deliveries of firemen and equipment into fire localization zones;
- extinguishing fire using fire-extinguishing liquid carried in the external tanks; and,
- extinguishing fire using the artificial initiation of precipitation method from clouds located in the fire area by firing silver iodide charges at the clouds.

## Specifications of the An-26P

Number of airmobile firemen	30 men
Weights and payloads:	
Take-off weight	23,800 kg
Commercial payload (fire-extinguishing liquid or airmobile firemen with equipment)	4,000-4,400 kg
Number of packages of fire equipment (weight of one package is 100 kg)	10
Fuel reserve (taking into account a 580 kg emergency fuel reserve for 45 minutes of flight)	2,760 kg
Operating capacity of the two discharge devices	4,000 liters
Number of meteorological pyrotechnics fired	384
Flight data:	
Range of flight operating altitudes (with brief descent into the fire zone)	1,200-1,500 m
Operating radius	430 km
Operating flight speed	400 kph
Flight speed at the moment the fire-extinguishing liquid is discharged	230-240 kph
Fire-extinguishing liquid discharge time	2 seconds

The An-32 was demonstrated at the exhibition in the ordinary transport configuration.

### Specifications of the An-32

<b>Cargo compartment dimensions:</b>	
Length	12.48 meters
Maximum width	2.78 m
Maximum height	1.84 m
<b>Number of seats in the compartment:</b>	
To transport passengers	50
To transport patients on stretchers	24
Number of transported pallets	4
<b>Engines:</b>	
Number and type	Two Progress ZMKB Series 5 AI-20D
Output	2 x 3,810 kVt
<b>Weights and payloads:</b>	
Maximum take-off weight	27,000 kg
Maximum commercial payload	6,700 kg
<b>Flight data:</b>	
Flight cruising speed at the most advantageous altitude of 8,000 m	470-530 kph
Service ceiling	9,400 m
Take-off run	760 m
Landing run	470 m

A model of the An-70T future transport aircraft designed to replace the An-12 aircraft in the CIS countries' air forces and civil aviation was demonstrated on the ramp of the ANTK [Aircraft Scientific Technical Combine] imeni O.K. Antonov.

The An-70T is manufactured based on a normal aerodynamic design with a high wing. Composite materials were widely used in the design of the airframe. The power plant consists of four D-27 turboprop engines (4 x 13,880 horsepower) developed at the Progress NPO [Scientific Production Association] (Zaporozhye, Ukraine), which have coaxial propellers (engine flight tests were conducted in 1992 at the LII [Flying-Research Institute] imeni M.M. Gromov on an Il-76 flying laboratory aircraft; furthermore, more than 1,000 hours of test stand testing have been conducted). A digital fly-by-wire system [FBW] and cockpit multifunction color screen displays have been utilized in the An-70T aircraft.

A payload with a maximum weight of up to 30,000 kg can be accommodated in the larger diameter fuselage equipped with an aft ramp (up to 5,000 kg of cargo can be transported on the ramp). The cargo compartment is pressurized and loading-unloading operations have been mechanized to the maximum extent possible. The landing gear and powerful high-lift devices provide the capability to operate the aircraft from both concrete and dirt runways. Landing gear clearance can be adjusted, which ensures that the height of the truck bed and the height of the cargo hatch floor conform while conducting loading-unloading operations.

The An-70T aircraft's first flight is planned for the beginning of 1993. The aircraft is designed for 45,000 flying hours (20,000 sorties during a 25-year period) and six to seven man-hours of ground maintenance should be expended per hour of flying time.

It is planned to carry out series production of the aircraft at aircraft plants at Tashkent and Samara. The An-70T aircraft development program is being financed by the Russian and Ukrainian Governments.

The An-70T aircraft surpasses the An-12 aircraft by a factor of 1.5 in payload and by a factor of 1.4 in cruising speed; based on its specifications it most closely corresponds to the Euroflag FLA [Future Large Aircraft] European Consortium military transport aircraft being developed jointly by Belgium, Great Britain, Germany, Italy, Spain, Portugal, and Turkey. Like the Ukrainian aircraft, the FLA can be equipped with turboprop engines (although other power plant variants are also being examined), however, it has a somewhat lower take-off weight and payload weight. Furthermore, the rate of development of the European aircraft significantly lags behind the rate of development of the An-70T aircraft, which opens favorable prospects for sale of the An-70T aircraft on the international market to replace the obsolete An-8, An-12, Lockheed's C-130 Hercules, and Transall's C-160 transport aircraft.

### Specifications of the An-70T, An-12, and Euroflag FLA

	Type of Aircraft		
	An-70T	An-12	FLA
Year of first flight	1993	1956	2000
Maximum take-off weight, tonnes	123	61	115
Payload weight, tonnes	30	20	25
Type of engines	D-27	AI-20M	Type has not been determined
Maximum output, horsepower	4 x 13,800	4 x 4,250	
Flight range with maximum payload	5,530	3,600	5,000
Cruising speed, kph	750	550	750
Service ceiling	9,600	10,200	
Required runway length, m	1,800-1,900	2,200	

The ANTK imeni O.K. Antonov developed the design of the An-170 transport aircraft—a variant of the An-70 with a lengthened fuselage and increased wingspan that is designed to replace the Il-76 aircraft. However, preference was assigned to the Il-106 aircraft in a design competition.

## OKB imeni S.V. Ilyushin Aircraft

### The Il-106 Transport Aircraft

A model of the new Il-106 transport aircraft was demonstrated at "Mosaeroshow-92." The aircraft, a normal design with four TRDD [turbojet bypass engines] with a super-high-bypass ratio and vertical tail surfaces, belongs to the same class of aircraft as the American C-17 military transport aircraft and is obviously designed to accomplish the same missions.

Specifications of the Il-106	
<b>Engines:</b>	
Number and type	Four NK-92
Bench thrust	4 x 180 kN [kilonewtons]
<b>Weights and payloads:</b>	
Maximum take-off weight	258 tonnes
Transported payload	80 tonnes
<b>Flight data:</b>	
Cruising speed	820-850 kilometers per hour [kph]
Flight range	5,000 km
Take-off run	1,400 m

## 2. Helicopters

### The Mi-24 Army Combat Transport Helicopter

Demonstrated at "Mosaeroshow-92," the OKB imeni M.L. Mil Mi-24 helicopter is well known throughout the world as the former USSR's first fire support helicopter. Its development began in 1967 in parallel with preparation for series production, which saved quite a lot of time. A prototype model of the new helicopter took off for the first time in 1969 and series-production helicopters began to arrive at units in 1971. Later it was supplied to customers from 22 countries. By 1992, series production of the Mi-24 had ceased. The Mi-24 was produced in the following variants:

Mi-24	Initial variant with TV2-117 engines and the pilot's and gunner's seats positioned side-by-side
Mi-24D	First variant with TV3-117 engines and tandem placement of the pilot and gunner
Mi-24V	Variant with Shturm-V and R-60 guided missiles
Mi-24P	Variant with a gun
Mi-24R	Reconnaissance helicopter with wing tip pylons for placement of radiation/chemical/bacteriological reconnaissance systems and with removable optical-gunsight and radio command systems in the nose fairings
Mi-24K	Reconnaissance helicopter with artillery fire observer
Mi-25	Export variant of the Mi-24D
Mi-35	Export variant of the Mi-24V
Mi-35P	Export variant of the Mi-24P

The Mi-24 is capable of destroying enemy tanks, storming enemy fire positions and defensive positions, escorting transport-assault helicopters and conducting aerial combat, adjusting artillery fire, dropping small assault subunits and reconnaissance teams into the enemy rear area, conducting radiation and chemical reconnaissance, and evacuating wounded personnel from the battlefield. This was one of the world's most effective helicopters until the end of the 1970's. In 1975 and 1978, seven world records, including the absolute speed record—367 kph in 1978, which was held for approximately 10 years—were established in the variant of the Mi-24 that received the designation A-10. The helicopter was tested under fire in many wars and military conflicts (Afghanistan, Iran, Iraq, Angola, Mozambique, Syria, Libya, Yemen, and Ethiopia), where it proved itself to be a reliable ground troops fire support system. It was also utilized for operations against airborne targets: The Iran-Iraq War episode when an F-4 Phantom fighter aircraft was shot down by gun fire from an Mi-24 serves as the most graphic example.

The fundamental difference between the Mi-24 and Western helicopters is the compartment for a squad of assault troops (eight men). Initially, the crew of the Mi-24 included two men: the pilot and the weapons operator. Then the flight engineer was introduced into the crew, whose work location is located in the assault compartment. Up to now, the Mi-24's engines, developed at the OKB imeni V.Ya. Klimov under the leadership of General Designer S.P. Izotov, are at the level of the world's best models based on specific and weight specifications. The Mi-24's special equipment includes an optical-electronic (infrared and television for low levels of illumination) surveillance-gunsight system in the right nose ventral fairing and a radio command missile guidance system in the left nose ventral fairing, a PKB gunsight (on the Mi-24V), a HUD (head-up display), a radar illumination warning receiver, an IR jamming system, an identification friend-or-foe system (IFF), a gun camera, ASO-2 pods with 132 decoys, and a UHF communications system. The flight-navigation system includes an autopilot, a radio altimeter, an instrument flying system, a DISS [Doppler slip and drift sensor], an ARK [aircraft radio compass], and mechanical indicators with a moving terrain map.

At first, the Mi-24 was armed with four Falanga subsonic PTUR's [antitank guided missiles] with manual control (later with a semiautomatic control system): two anti-tank guided missiles, each located on the wing tip pylon launch rails. Beginning with the Mi-24V they were replaced with Shturm-V 9K113/9M114 supersonic anti-tank missiles, the number of which on the wing tip and underwing pylons reaches 12. R-60 close-range guided missiles, UB-32-57 or UB-20-57 unguided rocket pods with S-5 (32 x 57 mm or 20 x 57 mm), S-8 (80 mm) or 240 mm unguided rockets, a UPK-23-250 standard gun pod with a GSh-23L gun (23-mm, a basic load of 250 rounds, dimensions 340 x 450 x 3,000 mm), pods with machine guns or grenade launchers, up to 1,500 kg of chemical or conventional bombs, canisters with mines,

etc., can be installed on the four underwing pylons instead of antitank guided missiles. The helicopter can land and reload its weapons with ammunition located in the compartment.

The gun has also undergone changes. The first Mi-24's had a single-barrel machine gun, then a four-barrel 12.7 mm machine gun with a rotating barrel unit was installed in a USPU-24 ventral, standard machine gun mount with electronic remote control.

#### Specifications of the USPU-24 [Standard Machine Gun Mount]

Dimensions:	
Diameter of the base	630 mm
Height	580 mm
Type of machine gun	9A-624 four-barrel
Caliber	12.7 mm
Rate of fire	4,800 rounds per minute
Basic load	1,400 rounds
Deflection angles:	
Elevation	from +20 to -60°
Azimuth	from +60 to -60°
Weight of the mount	80 kg

Since 1980, initially the Mi-24P gun variant was armed with a GSh-30-2 30 mm twin-barrel gun with a basic load of 250 rounds in the right fuselage fairing and then with a 23 mm gun on a mobile mount.

### The Ka-50 Fire Support Helicopter

The OKB imeni N.I. Kamov Ka-50 new generation army combat helicopter, whose primary missions on the battlefield are troop fire support, covering armored vehicle combat operations, and opposing enemy army aviation, was demonstrated in flight for the first time at "Mosaeroshov-92." This is the first employment in world practice of a single-seat helicopter to accomplish this type of mission. The helicopter's first flight occurred on 17 June 1982 (test pilot Nikolay Bezdetnov). A large amount of modeling was conducted in the process of its development, hundreds of flights were made in a flying laboratory, experimental and prototype models of the Ka-50 accumulated several thousand flying hours, firings were conducted from the gun, and unguided rockets and antitank missiles were launched. The conclusion of the customer's test pilots—the helicopter is accessible for line unit pilots with medium skills.

Development was conducted on a nontraditional competitive basis for Russian helicopter manufacturing and, in the process, the task was assigned to develop a domestically produced helicopter that did not lag behind the specifications of the American AH-64 army combat helicopter.

Four possible designs were examined during the validation of the Ka-50's appearance: single-rotor with a tail rotor, longitudinal, dihedral, or coaxial, and the latter was chosen which, besides higher combat survivability, ensures the helicopter's heightened efficiency in a hover and at low flight speeds and while gaining altitude and an increased static ceiling with equal engine output, simplified flying (due to the lack of cross links in the control channels as a result of the helicopter's aerodynamic symmetry, and improved maneuverability (for example, a flat turn capability)). Furthermore, a coaxial design helicopter has a reduced visual and radar cross section due to its smaller geometric dimensions.

The decision to assign one crew member to accomplish combat missions also determined the Ka-50's appearance. That decision was made taking into consideration the experience of the combat employment of the Mi-24 helicopter, the operation of which, in the opinion of General Designer S.V. Mikheyev, demonstrated that the pilot's tasks (piloting and navigating the helicopter with the goal of undetected access to the target search and attack area at extremely low altitudes) largely do not intersect with the operator's tasks (target search and attack using antitank missiles). Honored Combat Pilot of the USSR, Hero of the Soviet Union, Russian Ground Forces Army Aviation Commander in Chief Lieutenant General V. Pavlov thinks that an independent safe search for targets by a combat helicopter in conditions of strong PVO [air defense] or a search for targets that are using modern camouflage systems is a very difficult task. Therefore, in any case, this requires the transmission of a preliminary target designation to the attacking helicopter which is necessary not only to ensure that it is not detected but also to organize helicopter group operations. The latter circumstance (operations by a well-organized group) is an important element for the success of an attack. Everything listed, especially high maneuverability, the need for which was confirmed in Afghanistan, and the simplicity of piloting a coaxial design helicopter, played a decisive role in the development of precisely a single-seat combat helicopter.

The Ka-50 helicopter was designed taking into consideration the improvement of serviceability. It has built-in equipment operability monitoring systems, and has been provided with convenient access to equipment without utilizing ladders. Servicing the weapons systems, electronic systems, refueling, and loading are carried out from the ground. Power plant servicing from the cowlings-ladders and servicing of the main rotors is carried out from the upper surface of the fuselage. System design provides for combat utilization of the Ka-50 with prolonged separation (more than two weeks) from main bases.

A distinguishing feature of the Ka-50 is the completely armored cockpit that protects the pilot from up to 20-mm rifle and cannon weapons. The cockpit is equipped with a K-37 seat that was designed for it. The K-37 ensures the rescue of the pilot during ejection at any altitude. The rotor blades are jettisoned before

ejection. This is the first employment in the world of an ejection system in a helicopter that has been proposed for series production.

It has a tricycle landing gear with the nose gear retracted in flight which permits reduction of the helicopter's aerodynamic resistance and its radar cross section. Flight with the landing gear extended is authorized in the entire range of speeds while flying at extremely low altitudes in the event an emergency landing has to be carried out.

Modified engines have been installed on the Ka-50, which have proven themselves in operation on the Mi-24 and are equipped with dust-protection and exhaust screen devices.

A single gunsight-flying-navigation system which permits one crew member to both fly and conduct fire from all types of weapons has been developed for the Ka-50 for the first time in the practice of domestic helicopter manufacturing. The optical gunsight system (OPS) installed on the helicopter ensures target search and automatic guidance of antitank missiles to the target. A helmet-mounted target designation system has been employed that relieves the pilot of the task of controlling the optical gunsight system. The pilot is freed from the need to maintain a certain trajectory of movement and the helicopter can complete altitude and course changes and change flight speed after launch in the process of guiding the antitank missile. It has a HUD on which flight and also gunsight information for employment of the gun and unguided rockets is depicted. Information on the status of onboard systems is transmitted to the pilot and information is also utilized that is received via radio channels from reconnaissance helicopters. The helicopter REP [electronic countermeasures] system shows no lag behind the Apache helicopter's similar system in its functional indicators.

The Ka-50 has four weapons hard points under its wing on which up to 16 supersonic antitank guided missiles or up to 80 80-mm unguided rockets (in four 20-tube pods) can be suspended. Employment of other types of removable weapons is also possible. Antitank guided missiles support the attack of targets outside the zones of destruction of enemy antiaircraft missile systems and a high probability of hitting small targets in the entire spectrum of missile launch ranges. The antitank missile's launch range is 8-10 km, it has the capability of piercing 900 mm of armor with dynamic protection, and it has a laser guidance system.

An important feature of the Ka-50 is the employment of the 2A42 tank gun (it is also utilized on the BMP-2) with a high armor-piercing capability and the capability for recoilless operation in dust, sand, and dirt. The 30-mm gun has selective feed and a variable rate of fire and the basic load of up to 500 rounds is located in two ammo boxes in the central section of the helicopter. The unusual solution was realized thanks to the compromise that was found—rigid attachment of the gun's rotating

gun mount to the starboard side of the fuselage in such a way that a turn of the gun in the vertical plane is carried out by a servo in approximately the same range of angles as the AH-64 helicopter, and in the horizontal plane—by turning the entire helicopter (a flat turn). The tracking servo holds the gun on the target. Installation of the gun turret near the center of gravity ensures very high accuracy of fire. At low altitudes, the pilot uses the manual operating mode, at great distances—the precise automatic firing mode, the aiming of which is no different than aiming to launch an antitank guided missile.

The Ka-50 helicopter program has a high priority in the plans of the Russian Armed Forces and, therefore, work on the organization of Ka-50 series production continues despite a significant reduction in defense expenditures. The helicopter's entry into Russia's army aviation units is anticipated by the end of the year. The VNTK [Helicopter Scientific Technical Combine] imeni N.I. Kamov is seeking paths into the foreign market: in S. Mikheyev's words, they propose participating in the competition for a new combat helicopter that the British Army plans to announce by the end of 1992. The winning firm will obtain an order for the manufacture of 130 helicopters whose primary mission will be to combat tanks. A variant of the helicopter with Western equipment will be offered to Great Britain. In spring 1992 the OKB concluded an agreement with the American company Group Vector that envisions equipping the Ka-50 helicopter with Western systems and weaponry, which will make the Ka-50 more competitive in the foreign aircraft market, and organizing marketing of the helicopter.

### The Mi-28 Fire Support Helicopter

The Mi-28 combat helicopter was demonstrated for the first time at the 1989 Paris Air Show. Design of the Mi-28 began in 1980 and the first prototype helicopter left the ground on 10 November 1982. The helicopter was built based upon the single rotor design traditional for the OKB, selection of which was based on the results of the analysis of a large number of designs of the aircraft, including twin-rotor designs. In contrast to the Ka-50, this is a two-seat aircraft. OKB imeni M.L. Mil experts say that the mission of flying at extremely low altitudes (5-15 meters) over the earth's surface with complex relief and the simultaneous search for remote targets cannot be effectively accomplished by one man even if he is assisted by totally modern optics and electronics based upon current concepts. All the more so in that flying and destroying targets does not exhaust the crew's tasks—it also needs to avoid coming under fire from enemy air defense systems. Other helicopter manufacturing firms also assign a preference to the advantages of a two-man crew: all the world's helicopters in combat ranks are two-seaters.

The number of mechanical hinged joints, lubrication points, and joints with nuts requiring calibrated tightening were drastically reduced on the Mi-28 to increase serviceability. Attached ladders are not required when servicing the helicopter in the overwhelming majority of

cases and ease of access to assemblies has been achieved through rapid and total exposure of power plant cowlings and equipment compartment hatches. The Mi-28 has built-in monitoring systems. The average total labor-intensiveness of maintenance has been reduced by a factor of three in contrast to the Mi-24 helicopter and by a factor of three to nine on individual assemblies and systems. The Mi-28 can be transported in the cargo compartments of the An-22 and Il-76 aircraft with the main rotor blades and wings removed.

The Mi-28 helicopter was manufactured based on a single-rotor design with a tail rotor located on the right in flight (in contrast to the Mi-24 on which the tail rotor has been installed on the left in flight). Special attention was devoted to increasing the helicopter's combat survivability. During the selection of its configuration, the task was assigned to ensure mutual screening of assemblies and protection of more critical members by less critical members (for example, the engines have been separated by a distance that is adequate for placement of the main gearbox). The selected materials and dimensions of the members ensure the absence of catastrophic failures when damaged for a time that is adequate to carry out the mission with a return to base. For example, the fiberglass from which the main rotor and tail rotor blades are manufactured has high residual strength when damaged. The dimensions and spar sections were selected with the calculation that weapons of the most probable caliber will not cause an unacceptable loss of their durability when hit. The crew cockpit is protected with titanium armor with external ceramic plates and has armored glass with flat low-reflective panels.

The Mi-28 has a five-bladed main rotor and a titanium hub with elastomeric bearings. The blades have fiberglass D-shaped spars that are manufactured using the spiral fiber winding method, have Kevlar plastic sections with a Nomex-type filler, and anti-abrasive titanium pads have been installed on the leading edges of the blades. The blades have high load-bearing profiles and streamlined tips. The diameter of the main rotor was selected approximately the same as the Mi-24's so that the improved Mi-28 helicopter blade could subsequently be transferred to the Mi-24. The main rotor shaft is inclined ahead by 5° and the rotation of the main rotor is 242 rpm.

The crew is located in cockpits arranged in step fashion: the navigator-operator's work station is located in the forward cockpit and the pilot is located in the raised rear cockpit. The pilot's mission is to fly the helicopter and employ the unguided weapons and the navigator-operator's mission is search, detection, identification, and destruction of small targets at maximum range using precision-guided weapons and the gun and also helicopter navigation.

The X-shaped tail rotor consists of two two-bladed rotors with fiberglass blades. The rotors are installed at angles of 35/145° on one shaft on an elastomeric bearing (one three-bladed tail rotor was initially used on the first two prototype helicopters). The tricycle landing gear

with tail support is nonretractable. It has single-wheel landing gears, the sizes of the main tires are 720 x 320 mm, the operating pressure is 0.54 MPa, and the dimensions of the self-orientating tail wheel is 480 x 200.

The power plant consists of two TVZ-117 GTD [gas turbine engines] that have been installed in nacelles along the sides of the upper section of the fuselage over the engines, and the engine nozzles are canted downward. The engines have a modernized electronic adjustment system. The air intakes have dust protection devices and an anti-icing system with bleed air from the engines. The transmission can operate without lubricant for 20-30 minutes.

The AI-9V VSU [auxiliary power system] is utilized to start the engines and drive the electrical supply system and the hydraulic and pneumatic systems on the ground, which permits these systems to be maintained in operable condition for the required time without starting the main engines. The capacity of the internal fuel tanks is approximately 1,900 liters. Four external tanks can be suspended on the underwing pylons.

The helicopter has a hydromechanical control system. Control of the stabilizer is linked with control of the main rotor collector pitch. Only the pilot has flight control elements. Systems control has been integrated to the maximum extent possible. The control elements that are used in flight—the "pitch-gas" lever and the control stick—are located on the left control panel and the control elements that are required only for preparation for flight are located on the right control panels. Depiction of secondary information on systems operation to the crew has been practically excluded. The pilot's cockpit has a HUD and a CRT [cathode ray tube] display in the center of the instrument panel to depict optical-electronic system data.

OKB experts think that crew ejection from a helicopter in emergency situations has too many shortcomings and preferred a crew rescue system without leaving the helicopter. Energy-absorbing seats with a gravitation system to create the required preparatory position and an undercarriage with an increased shock-absorber stroke ensure survival for the crew during emergency landings when the helicopter hits the ground at high (up to 12 meters per second) vertical speeds and at high speeds when the ground is hit sidelong or head-on. Design steps have been taken that prevent members of the crew from colliding with control elements and interior elements and also prevent systems and assemblies that are outside the cockpit from ending up inside the cockpit. Sensors and mechanisms automatically turn on the rescue system if the crew does not manage to turn it on in the manual mode for some reason. The probability of a post-accident explosion or fire has been reduced. Parachutes have been provided for a possible departure from the aircraft from high altitude and emergency jettisoning of the cockpit doors and inflation of pneumatic cells located under the threshold of the doors (to exclude a collision with the undercarriage) occur prior to a jump.

There are two hydraulic systems with an operating pressure of 15.2 MPa and a 200 volt alternating current electrical supply system with two generators.

The surveillance-gunsight system—the navigator-operator's primary system to guide antitank missiles and fire from the gun—has been installed on a gyro-stabilized platform and has a great deal of mobility (+/-110° along the azimuth). In the day variant, the system has two optical channels with wide and narrow fields of view and an optical-television channel with a narrow field of view. A laser rangefinder-target designator has also been provided that is used to determine its current range to the target, to calculate adjustments in the automatic mode while firing from the gun and while launching unguided rockets, and also for selection of the optimal trajectory for an antitank missile at the moment of launch. These systems are also utilized to control a missile while it is being guided to the target. An IR system and a TV system for low levels of illumination can be installed for operations at night. It is also possible for the crew to use night vision glasses.

Firing is conducted using a HUD or a helmet-mounted gunsight that controls the mobile gun within visual range without using magnifying optics. The Vitebsk helicopter electronic countermeasures system (analogous to the Apache helicopter's AN/ALQ-136) has been installed. It has IR radiation suppression devices and automated decoy dispensers.

The weaponry of the prototype helicopters includes a turret mount with a 2A42 modified tank gun (30-mm; 900 round per minute rate of fire against airborne targets and 300 rounds per minute against ground-based targets; basic load 300 rounds), which has the same mobility as the gunsight (+/-110° along the azimuth and +13 -40° in elevation) and synchronously follows it.

Moscow's Dzerzhinets Assembly Plant is developing a fixed mobile (the previous range of mobility has been maintained) gun specially for the Mi-28. A single-barrel 30-mm gun with selective feed is being utilized. The rate of fire is 300 and 600 rounds per minute and the basic load is 250 rounds. The weight of the NPPU [fixed mobile gun mount] with a basic load and the gun is 620 kg, the weight of the control apparatus is 45 kg, and the dimensions of the NPPU are 1,730 x 1,100 x 750 mm.

There are two hard points under the outer wing panel, each of which is designed for a load of up to 480 kg. Up to 16 Shturm antitank guided missiles with a radio command guidance system and two pods with 20 57-mm or 80-mm unguided rockets are suspended under the wing. Firing from the gun and launching antitank missiles are carried out only by the operator from the forward cockpit and unguided rockets can be launched from both cockpits.

### Comparative Specifications of Contemporary and Future Combat Helicopters

	Type of helicopter		
	Ka-50	Mi-24P	Mi-28
Year of first flight	1982	1969	1982
Year production initiated		1971	
Production volume		2,310	
<b>Dimensions:</b>			
Diameter of main rotor, m	14.5	17.1	17.2
Length with rotating rotors, m	16	18.8	
Height, m		4.2	4.8
Crew, men	1	3	2
<b>Engines:</b>			
Number and brand	2 TVZ-117	2 TVZ-117	2 TVZ-117
Output, kVt	2 x 1,618	2 x 1,618	2 x 1,618
<b>Weight and payloads, kg:</b>			
<b>Take-off</b>			
Maximum		11,500	11,200
Normal		11,200	10,400
Weight of empty helicopter		8,200	7,000
Combat payload		2,500	3,640 <sup>ss</sup>
<b>Flight data:</b>			
Maximum speed, kph	350 <sup>*</sup>	330	300
Hovering ceiling, m	4,000	1,500	3,600
Time-to-climb, mps:m	10:2,500	12.5:0 [as published]	
Range with internal fuel reserve, km		500	475
Maximum flight duration, hours		4	2
Maximum operational G-load	3	1.75	3.0/-0.5

\* With a gunsight system

<sup>ss</sup> In a flat dive

### OKB imeni M.L. Mil Future Aircraft

Information on future military or dual-purpose helicopters that have been developed at this collective was presented at the MMZ [Moscow Machine Building Plant] imeni M.L. Mil Pavilion.

A drawing of a future helicopter—the Mi-40 infantry fighting aircraft developed based on the Mi-28 helicopter's main rotor design and power plant—was displayed. The Mi-40 helicopter is designed to equip airmobile rapid deployment forces units and is equipped with a built-in twin-barrel 23-mm gun which is mounted in a new type of remotely controlled nose turret with an

increased field of fire. Furthermore, it is proposed arming the helicopter with future antitank missiles and unguided rockets.

The helicopter's avionics ensure its effective combat employment in complex weather conditions and at night. An assault team of eight-10 men is located in the fuselage and can conduct fire against groundbased targets using organic weapons.

**Specifications of MMZ imeni M.L. Mii  
Future Helicopters**

	Type of helicopter			
	Mi-30	Mi-40	Mi-46T	Mi-54
Normal take-off weight, kg	3,250	10,400		
Maximum take-off weight, kg	3,750	11,500	30,000	4,000
Maximum payload, kg (capacity, men)	(5)	(8-10)	10,000	1,300
Number and output of engines, horsepower	2 x 650			2 x 550
Maximum speed, kph	530	295	270	260
Static ceiling, m	2,700	3,600	2,300	2,000
Operating range, km			460	400*
Weaponry		1 x 23-mm gun, antitank missiles, unguided rockets		

\*With a 10,000 kg payload

A convertible aircraft with a tilting wing, on which two large diameter propellers have been installed (design similar to the design of the American V-22 Osprey aircraft) and which accommodates five people, is designed to carry out a wide circle of military and civilian missions (transport, patrol, rescue operations, reconnaissance, etc.).

The Mi-54 helicopter is designed to replace the Mi-2 and Mi-4 multimission helicopters which are widely operated in our country and abroad.

The Mi-46T heavy helicopter is called upon to replace the Mi-6 transport helicopter and the Mi-10K helicopter-crane.

### 3. Trainer Aircraft

A model of the Yak-UTS trainer aircraft was displayed at the OKB imeni A.S. Yakovlev Pavilion. Besides the aircraft, the training system includes simulators and automated training systems using personal computers. The Yak-UTS is designed to replace the Czech-made L-39 Albatros trainer aircraft of the CIS countries' air

forces and was selected based upon a competition in which, besides the OKB imeni A.S. Yakovlev, the OKB's imeni A.I. Mikoyan, P.O. Sukhoy, and V.M. Myasishchev participated. The new aircraft's first flight could occur in 1994-1995 and the beginning of series production in 1995-2000.

The aircraft is manufactured according to a normal aerodynamic design with a wing that has developed wing extensions and winglets. The aerodynamics and high thrust-to-weight ratio (0.6-0.7) provide the capability to fly in modes close to those of fourth generation fighters (specifically, flight is possible with an attack angle of up to 32°).

The twin-seat cockpit with a single canopy provides a good field of view for both the pilot and the instructor. Two multifunction CRT displays with screen sizes of 130 x 130 mm will be installed on the instrument panels, and it also has a HUD.

It is proposed equipping the aircraft with two AI-25TLM turbojet bypass engines (Progress NPO (Scientific Production Association), Zaporozhye) that have a service life of 1,000 hours. In the future it is proposed employing better engines developed at the OKB imeni V.Ya. Klimov (in contrast to the AI-25TLM turbojet bypass engines with afterburner, they propose increasing the thrust by 15%, economy by 4%, service life must total 4,000 hours and must increase to 6,000 hours in the future). A 700-liter capacity conformal external fuel tank can be installed under the fuselage.

The aircraft's control system is hydromechanical and they envision reconfiguring it to imitate flight in various types of aircraft.

The UTS is equipped with an inertial navigation system, a radio navigation system, a radio altimeter, a video recorder, and K-36 ejection seats. A laser gun-simulator and also laser radiation receivers (smoke generators that imitate destruction in aerial combat should be switched on automatically when the "enemy" aircraft's laser beam hits them) will be installed in the aircraft to train in conducting aerial combat.

Airframe service life should total 10,000 hours and could increase to 15,000 hours in the future, which corresponds to UTS operation for 30 years.

Besides the basic trainer variant, a carrier-based UTS is being developed that is equipped with a folding wing, reinforced landing gear, and arresting hook.

It is proposed developing a four-seat UTS with two two-seat cockpits to train bomber aviation pilots. It is proposed utilizing the carrier-based variant of the four-seater aircraft as a transport-passenger aircraft for rapid delivery of people and light cargo to aircraft-carrying ships (maximum cruising speed—650 kph, operating range—2,000 km).

A single-seat strike variant of the aircraft with augmented weaponry and onboard radar is being developed for export deliveries.

**Specifications of the Yak-UTS Trainer Aircraft**

Wingspan	11.25 m
Aircraft length	12.40 m
Aircraft height	4.60 m
Sweep angle of wing along the forward edge	31°
Maximum take-off weight	5,500 kg
Weight of fuel in internal tanks	1,800 kg
Weight of fuel in the conformal tank	700 kg
Type of engine	AI-25TLM turbojet bypass engine with afterburner
Maximum thrust	2 x 17 kN
Maximum speed	850 kph
Ferry range with conformal external fuel tank	2,500 km
Take-off speed	180 kph
Landing speed	170 kph
Take-off run (concrete/dirt runway)	250/330 m
Landing run (concrete/dirt runway)	450/520 m
Maximum operational G-load	+8/-3

The T-501 UTS that was displayed at the exhibition is a future trainer aircraft developed by the OKB imeni A.I. Mikoyan. Construction of the first prototype T-501 UTS equipped with a TVD (turbojet engine) began in April 1992. Work is being financed by the firm RosAero-Progress (RAP), which concluded a contract worth R38 million with the OKB imeni A.I. Mikoyan at the beginning of 1992. Requirements for the UTS were coordinated with the CIS Air Force. It is proposed building two prototype aircraft for flight tests and also one aircraft for static tests. The first flight of the new UTS is planned for March 1993, and the flight of the second prototype aircraft is planned for June 1993. Aircraft model wind tunnel tests were accomplished at the ADT [wind tunnel] at TsAGI [Central Aero-Hydrodynamics Institute].

It is proposed equipping the T-501 aircraft with the TVD-10V engine (1 x 1,025 horsepower), the UTS's wingspan should total 11 m, length—9.66 m, wing area—16.5 m<sup>2</sup>, normal take-off weight—2,670 kg, maximum speed—560 kph, maximum rate of climb—21 mps, ferry range—1,800 km and, flight range at low altitude—1,000 km.

It is possible that an order will be received to build approximately 800 UTS's of this type.

The Czech L-59 Aero UBS that was demonstrated on the ramp and in flight was the only foreign combat aircraft presented at "MosAeroshow-92." The aircraft is the further development of the L-39 Albatros UBS widely used in the air forces of the CIS countries (more than 1,600 aircraft were delivered) and 14 other states.

The aircraft is equipped with a ZVL/Lotarev DV-2 turbojet bypass engine with afterburner and a Sapfir APU [automatic safety device]. Avionics include an RSBN [radio navigation system], an SRO-2M identification friend or foe system, an RV-5 radio altimeter, a HUD, and cockpit screen displays on CRT's. The two-man crew is located in VS-2 ejection seats in a cockpit under a single canopy that folds back and supports leaving the aircraft on the ramp. Aircraft weaponry with a total weight of 1,053 kg is located on five external hard points and can include a gun, two air-to-air guided missiles, bombs, and unguided rockets. Work is being conducted on a single-seat strike variant of the L-59 aircraft.

**Specifications of the L-59 Aircraft**

Wingspan	9.54 m
Aircraft length	12.20 m
Aircraft height	4.77 m
Wing area	18.80 m
Weight of empty aircraft	4,360 kg
<b>Normal take-off weight:</b>	
In the trainer variant	5,510 kg
In the strike variant	5,700 kg
Maximum take-off weight	6,613 kg
Weight of fuel in internal tanks (including wing tanks)	1,200 kg
Weight of fuel in external tanks (2 x 350 l)	544 kg
Maximum landing weight	6,000 kg
Maximum speed (N = 5,000 m)	875 kph
Maximum Mach number	0.82
Maximum rate-of-climb	25 mps
Service ceiling	11,730 m
Ferry range with external fuel tanks	1,500 km
Combat radius without external fuel tanks	1,210 km
Take-off run	640 m
Landing run	720 m

The new OKB imeni P.O. Sukhoy-designed Su-29T aircraft displayed at the exhibition is a two-seat variant of the well-known Su-26MKh sports-acrobatics aircraft that was also displayed. The Su-29 is designed for flight training, mastering the art of aerobatics by military and civilian pilots and air school cadets, for trainers and performances at aircraft sport competitions. The aircraft has high speed run and rate-of-climb specifications, good handling combined with low G-loads on the control elements and a 360° field of view from the cockpit. The high durability of the design (authorized G-load is 23) combined with a high seat angle of incline (35°) permits the pilot to repeatedly utilize a G-load of +12/-10° while flying, which gives the aircraft an advantage during flight in a restricted flying zone.

The aircraft is manufactured with wide employment of composite materials (more than 70% of aircraft design weight). The aircraft wing (twin-spar, one-piece) is totally manufactured from composite materials based upon

carbon plastics and plexiglass and the wing skin panels have a honeycomb filler. The central portion of the fuselage has a truss tubular welded frame made of high-tensile strength stainless steel and removable skin panels made from composite materials. The tail fairing and tail section of the fuselage are a semi-monocoque design made from composite materials. It has a tricycle landing gear with tail bumper. The primary wheels are installed on springs made from a titanium alloy and are equipped with differential disc brakes with a hydraulic drive.

The Su-29 is equipped with an M-14P air-cooled nine-cylinder radial piston engine with an output of 360 horsepower. It has a pneumatic engine ignition system. The capacity of the main fuel tank is 70 liters. It has two tanks built into the wing with a total capacity of 220 liters to ferry the aircraft.

The Su-29T single-seat variant is designed to train pilot-sportsmen and for their participation in acrobatic competitions and is distinguished from the two-seat variant by its reduced length and weight, boosted engine and, as a result, improved speed and maneuvering properties. There is a 140 liter external tank to ferry the aircraft, but two tanks built into the wing with a total capacity of 220 liters can be used instead.

It is proposed delivering 24 Su-29 two-seat aircraft abroad in 1992.

#### Specifications of the Su-29\*

<b>Dimensions:</b>	
Wingspan	8.20 m
Aircraft length	7.29 (6.83) m
Aircraft height	2.74 m
<b>Engines:</b>	
Number and type	1 M-14P PD [piston engine] (M-14PF)
Output	360 (400) horsepower
<b>Weights and payloads:</b>	
Maximum take-off weight	1,100 (780) kg
Weight of empty aircraft	670 kg
<b>Flight data:</b>	
Maximum permissible speed (not to exceed)	450 kph
Maximum horizontal flight speed	330 (340) kph
Take-off speed	120 (110) kph
Landing speed	115 (105) kph
Rate-of-climb at sea level	18 (19) mps
Service ceiling	4,000 m
Take-off run (Su-29T)	140 m
Landing run (Su-29T)	250 m
Maximum roll rate	6 (7) radians per second
Maximum operational G-load	+12/-10

\*The differentiating data of the Su-29T variant is cited in parentheses

#### 4. Aircraft of Special Designs

The work of R.L. Bartina and R.Ye. Alekseyev that laid the foundations of wing-in-ground effect vehicles in the USSR created a solid foundation for the further development of aircraft using the screen effect which, according to some assessments, could become the primary type of long-range transport in the next century.

Nizhniy Novgorod's Central KB [Design Bureau] for Ships and Hovercraft NPO is undertaking efforts to expand the sphere of application of the Orlenok wing-in-ground effect vehicle, which was developed in the 1970's, as a transport vehicle for the Navy. Five vehicles have been built thus far and three of them are in operation. In 1992 the use of the Orlenok in the Mriya-Orlenok aviation-maritime search and rescue system was proposed.

The An-225 Mriya was developed in 1985-1988 and its first sortie occurred on 21 December 1988. By the beginning of 1992 it had completed approximately 400 flights with a total duration of approximately 600 hours, including 36 flights with the Buran reusable spacecraft. The proposed system consists of an aircraft-platform based upon the Mriya and a rescue wing-in-ground effect vehicle based upon the Orlenok. They assume that the Mriya-Orlenok system will be based at civilian or military coastal airfields. When a distress signal is received, the aircraft-platform will fly to the accident area and conduct a search if necessary. As soon as the object of the search has been found, the wing-in-ground effect vehicle will start engines and separate from the aircraft-platform. The wing-in-ground effect vehicle's developed wing permits it to carry out a gliding descent and a landing on water. In the event that the accident object is located outside the range of the aircraft-platform, the wing-in-ground effect vehicle is separated at the maximum possible distance from the basing airfield (at the "drop point") and carries out the remaining portion of the trip independently.

The system platform will be somewhat different from the basic Mriya aircraft. It requires installation of special communications, search and onboard auxiliary equipment, and also development of strong hard points and an attachment and separation system for the Orlenok wing-in-ground effect vehicle.

Five Mriya-Orlenok systems, dispersed along the water area of the World Ocean and united in a single international rescue system, cover practically all zones of heavy navigation, fishing, and the maritime petroleum industry. The development and introduction into operation of this system will take four to five years and will be cheaper than designing another new aviation-maritime rescue system because the prototypes of both components of this system are already flying. With an operating period of 20 years, the system will already pay for itself in three years and will begin to yield a profit. Organization of an international rescue service is required to implement this program for rescuing people at sea.

**Specifications of the Mriya-Orlenok System**

<b>Aircraft-Platform</b>	
Wingspan	83.4 m
Length	84.0 m
Wing area	905.0 m <sup>2</sup>
Flight speed	700-750 kph
<b>Wing-in-Ground Effect Vehicle</b>	
<b>Dimensions:</b>	
Wingspan	30.6 m
Length of the wing-in-ground effect vehicle	58.1 m
Wing area	304.6 m <sup>2</sup>
<b>Weights and payloads:</b>	
Take-off weight (as part of the Mriya-Orlenok system)	140 tonnes
Passenger capacity	70 people
<b>Flight data:</b>	
Flight range (altitude 2 meters)	2,400 km
Flight speed	400 kph
<b>The An-225-Orlenok System</b>	
Take-off weight	610.0 tonnes
Drop point (emergency fuel reserve for one hour of flight)	2,400 km
Flight speed	650-700 kph

Negotiations between the Nizhniy Novgorod TsKB [Central Design Bureau] and the firm Aerocon (United States) on the issue of joint development of the new wing-in-ground effect vehicle occurred in January-March 1992. In 1989 Aerocon obtained a \$546,000 contract from the U.S. Department of Defense Advanced Research Programs Agency (DARPA) to study the wing-in-ground effect vehicle concept. The firm anticipates that another \$1 million will be allocated to continue the research. Although DARPA has reported that it does not plan to expand this program (transferring it to the stage of development and production), it is known that it enjoys the support of the U.S. Central Command staff, which has compiled official TTT [tactical-technical specifications] for a vehicle of this type, and the support of the U.S. Transportation Command staff. The advantages of wing-in-ground effect vehicles were demonstrated during the assessment of possible scenarios of potential wars. For example, two wing-in-ground effect vehicles can transport an American infantry brigade, equipped with guided weapons which can neutralize three to five enemy armored divisions, to a crisis zone in one trip.

**Comparative Cost of Trip From New York to France**

Method of transportation	Time	Cost, U.S. dollars	Number of seats
Ocean liner (New York-Cherbourg)	5 days	1,795	1,860
Boeing-747 airliner (New York-Paris)	7 hours	1,944	400
Concord airliner (New York-Paris)	3 hours, 45 minutes	6,388	100
Wing-in-ground effect vehicle (New York-Cherbourg)	6 hours	200	3,000

According to Aerocon spokesmen, approximately \$15 billion would be required for a demonstration program that envisions the construction of 12 wing-in-ground effect vehicles over a 15-year period. In the event resources are allocated, the first wing-in-ground effect vehicle flight could occur in five years. The cost of one wing-in-ground effect vehicle is \$500-700 million.

Efficiency and the low cost of a ticket will be the primary feature of the civilian variant. A wing-in-ground effect vehicle can be employed for military purposes to transport either 32 helicopters, 20 tanks, four hydrofoils, or 2,000 servicemen and 1,350 tonnes of cargo.

**Specifications of the Wing-in-Ground Effect Vehicle based on the TsKB Design for SPK [Joint Production Combine]/Aerocon**

<b>Size:</b>	
Wingspan	100 m
Length	170 m
Height	35 m
<b>Number of seats:</b>	
Passengers	3,000 people
Soldiers with military equipment and gear	2,000 men
<b>Engines:</b>	
Number and type	20 jet engines
Stand thrust	20 x 395 kN
<b>Weights and payloads:</b>	
Take-off weight	3,000 tonnes
Cargo capacity	1,500 tonnes
<b>Flight data:</b>	
Cruising speed	800 kph
Flight range	16,000 km
Flight altitude	2-10 m

Irkutsk State University (IGU) laboratory complex exhibits that were presented at "Mosaeroshow-92" aroused interest. IGU demonstrated a model of a wing-in-ground effect vehicle-flying wing with a hydrofoil undercarriage (ShVP) that is being studied under the "Skat" program. The combination of a wing-in-ground effect vehicle with a hydrofoil undercarriage permits us to support basing without airfields with a corresponding increase of the effectiveness of transport operations when existing wing-in-ground effect vehicles are adapted for take-off and landing from a single type of take-off and landing surface—from the water or from an airfield with a hard covering.

It is proposed using the aircraft that was demonstrated as the primary system to carry out transport missions in the areas of Siberia and the North. The economic effect of its introduction is potentially very great because this transport does not require the creation of a network of causeways or prepared airfields and can be operated around the clock on any ground. The hydrofoil undercarriage permits it to move practically at any speed, beginning from the hover mode with zero forward speed to a transition speed to wing-in-ground effect flight with a high aerodynamic quality at speeds of 700-900 kph. Low pressure on the ground in a static hydrofoil (0.06-0.07 atm [atmospheres]) does not have a substantial impact on the ground which, in combination with the employment of hydrogen engines as a power plant, makes this type of transport ecologically clean and harmless.

The undercarriage has a cupola design with a stiff, sectioned, spring-loaded enclosure: there are stiff flaps on the lower surface of the flying wing that tilt with the creation of a multichamber cupola under the wing in which a static air pillow is created by bleeding air from the gas turbine engines. The static air pillow is required for take-off and landing. The flaps are retracted into the wing contours in cruising flight and are included in the design-power plant design to increase the load ratio for a commercial payload.

The wing-in-ground effect vehicle-flying wing's high aerodynamic quality ensures its high transport effectiveness, a commercial payload may reach 50% of take-off weight and the cost of one tonne-kilometer will be 1.5-2 times lower than for transport aircraft of the beginning of the 1990's. The wing-in-ground effect vehicle is being studied in two main variants:

- for medium and long-range (2,000-20,000 km) cargo transport movements with high transport effectiveness in the form of a delta wing with a thick S-shaped profile that provides an aerodynamic quality of from 25 to 35 (in various configurations); and,
- for short-range (1,500-2,000 km) cargo transport movements with moderate transport effectiveness in the form of a flying wing-flat platform.

Take-off weight, tonnes	Carried cargo, tonnes	Maximum cruising speed, kph	Range, thousands of kilometers
1	0.3	290	1,440
8	2.8	440	2,870
27	10.8	495	4,680
64	28.8	565	4,950
125	59	630	5,530
216	108	695	6,030
343	172	755	6,300
512	256	810	7,130
729	365	855	7,570
1,000	500	900	7,880

It is assumed that wing-in-ground effect vehicles with a broad spectrum of take-off weights (on succeeding scales) can be developed.

The latest vehicle in this series (with a take-off weight of 1,000 tonnes) must have a wing area of 1,800 m<sup>2</sup>, a cruising speed of 720-900 kph, a maximum practical range with a full payload of 7,000 km, with a carried payload of 250 tonnes—10,000 km, and an aerodynamic quality of 30 with a relative altitude over the screen of 0.1 and aerodynamic quality of 25 with a relative altitude of 0.2.

So far, the IGU laboratory complexes jointly with Irkutsk Aviation Production Association have created a manned stand. By the end of 1992 they planned to build the first experimental manned model of a wing-in-ground effect vehicle-flying wing and designs of possible series-produced vehicles are being developed. With adequate amounts of financing, research of experimental manned models and construction of prototype models will be completed by 1996 with subsequent test operation of prototype vehicles in 1996-2000. The results of the laboratory's work were demonstrated at international exhibitions in the United States (Seattle) and Germany (Hanover) and also at VDNKh [Exhibition of the National Achievements of the Economy] at the "Ecologically Clean Transport" Exhibition. In May 1993, Irkutsk University proposes to organize the First International Conference on Wing-in-Ground Effect Vehicles under the chairmanship of M.P. Simonov.

At "Mosaeroshow-92," Moscow's EKIP production firm displayed information on a family of wide-fuselage highly economical aircraft that do not require airfields, with a cargo capacity from two to 200 tonnes, capable of carrying out both free as well as wing-in-ground effect flight and have low fuel consumption (from 10 to 14 grams per passenger-kilometer). The aircraft will be able to take off from any category of airfield, including water surfaces. The vehicles have a design that is close to the "flying wing" design with a load-bearing fuselage in the shape of a thick, low-aspect-ratio wing and small winglets. According to calculations, the vehicle's patented shape permits reduction of the weight of the design by reducing the level of the aerodynamic loads and their equal distribution along the surface of the vehicle, reduction of inductive resistance

and an increase of the aerodynamic quality (up to 17-25 in free flight and 22-30 during flight near the ground) due to a reduction of the required lift coefficient (as a result of the increase of the aerodynamically lifting area), and an increase of the volumes of cargo-passenger compartments

by eight to 10 times, in contrast to passenger transport aircraft comparable in cargo capacity. A patented device for controlling boundary currents that provides attached flow and a hydrofoil undercarriage have also been employed on EKIP's vehicle.

**Specifications of the EKIP Family of Aircraft**

	L3-3	L3-1	L3-2	L4-1	L4-2
<b>Dimensions:</b>					
Wingspan, m	14.4	31.3	55.5	91.6	128
Aircraft length, m	11	20	33.6	59	82
Aircraft height, m	3.1	6.7	11.8	19.6	27.5
Area in the plane, m <sup>2</sup>	88	400	1,250	3,430	6,860
Area of the hydrofoil, m <sup>2</sup>	23.8	75	235	640	1,280
<b>Engines:</b>					
Number and type	4 AL-34	2 D-436	2 NK-92	6 NK-92	10 NK-92
Thrust, ts [tonne-force]	4 x 0.85	2 x 7.0	2 x 18	6 x 18	10 x 18
Fuel consumption, grams per passenger kilometer	14	11	10-11	10-11	10-11
Power-to-weight ratio	0.38	0.4	0.33	0.36	0.3
<b>Weights and payloads:</b>					
Total weight, tonnes	9	35	110	300	600
Payload/number of passengers, tonnes/people	2.5/24	10/80	35/300	100/1,000	200/2,000
Structural mass, tonnes	5.0	15	40	100	200
Fuel, tonnes	1.5	10	40	100	200
Average wing load, kg/m <sup>2</sup>	102	88	88	88	88
Average flotation pressure, kg/m <sup>2</sup>	380	470	470	470	470
<b>Flight data:</b>					
Flight speed, kph	470-650 (identical for all)				
Flight altitude, m	5.5-6.0	8.5-10	8.5-10	8.5-10	8.5-10
Flight range, km	2,000	4,500	8,600	8,600	8,600
Take-off run, m	400	450	500	500	500
Runway type	dirt/water (identical for all)				

At the exhibition, the OKB imeni P.O. Sukhoy disseminated information on the development of the S-90-200 highly comfortable passenger amphibious wing-in-ground effect vehicle which has been ongoing for several years now. Development is based on a preliminary agreement with the Singapore firm Aero Marine. This twindeck liner is designed to transport passengers and cargo on medium and long routes that run primarily over a water surface with poorly equipped stopping points. The configuration of the upper deck envisions two salons: first class for 39 passengers and tourist class for 54 passengers. Eight cabins are located on the lower deck. The capability to embark and disembark passengers on shore in locations that are not equipped with piers is the outstanding feature of this vehicle. The wing-in-ground effect vehicle must ensure flight safety over the sea in areas with a large number of islands and intense navigation.

**Specifications of the S-90-200**

Wingspan	61 m
Vehicle length	40 m
Vehicle height	11.5 m
Maximum take-off weight	132 tonnes
Maximum payload weight	25 tonnes
Crew	14 people
Number of passengers	210 people
<b>Power plant:</b>	
Number and type of engines	2 NK-92
Output	2 x 8,832 kWt
Maximum cruising speed	470 kph
Flight range with maximum fuel reserve	8,000 km
Flight altitude over the ground	3 m
Maximum flight altitude	5,000 m

The OKB imeni G.M. Beriyev A-40 multimission amphibious aircraft demonstrated at "Mosaeroshow-92" in flight and on the ramp was developed for long-range antisubmarine warfare operations, with the capability to develop various civilian modifications for broad employment in island and coastal areas that do not have an adequate number of airfields and also on water areas of the world ocean. The A-40 is being offered in passenger, cargo-passenger, search and rescue (the Be-42), and other variants. It can carry out the replacement of crews of surface ships and conduct patrol operations in a 200-mile economic zone. The Be-200 shortened variant is being developed based on it.

The A-40 aircraft was demonstrated publicly for the first time outside the USSR at the Paris Air Show in July 1991. By that time the aircraft had established 14 world records, including raising a 10-tonne cargo payload to an altitude of 13,281 m and cargoes of 1, 2, and 5 tonnes to an altitude of 13,367 m. The A-40 aircraft's maximum flight weight reached 69,300 kg while establishing the records.

The A-40 is a cantilever monoplane with a high sweptwing and T-shaped tail fairing. More than 60 developments were acknowledged by inventors during the development of the Albatros. The high aspect ratio wing has a sweep of approximately 27° along the leading edge. Mechanization of the wing trailing edge consists of two mobile double-slotted flaps that occupy a large portion of the span and leading edge slats are located along the entire sweep of the leading edge. Nonretractable floats that serve to increase the aircraft's stability on the water have been installed on short pylons on the wing tips. There is an aft water rudder. It has a single-step hull with a high aspect ratio.

A variable-rise bottom has been developed for the first time in world practice, which permitted significant improvement of the aircraft's stability and controllability while moving through the water and also a reduction of G-loads during take-off and landing. Honeycomb bonded structures and nonmetallic materials have been widely employed in the aircraft airframe. A 6.10 meter-long weapons compartment has been located in the aft section of the hull. It has a tricycle landing gear with a nose gear and the main gears retract into large fairings located behind the wing. The base of the undercarriage is 14.835 m (between the centers of the wheels), and the track is 4.980 m (along the central points of the twinned wheels).

The aircraft is equipped with two Perm Aviadvigatel [Aircraft Engine] NPO [Scientific Production Association] D-30 KVP turbojet bypass engines, which are installed over the landing gear fairings behind the wing, preventing water from getting into the air intakes during take-off and landing. Additional protection from water is provided through the installation of strakes along the sides of the hull in the nose section and in front of the planing step. Two booster engines, located under the main turbojet bypass engines in the main gear fairings, serve to improve take-off characteristics from a water surface. The aircraft

has an aerial refueling system with a fuel reception probe located above the nose section of the hull.

There must be a radar with antenna in the nose fairing on the initial ASW [antisubmarine warfare] variant. Equipment to render antihypothermia, surgical, antishock, and other types of medical assistance are envisioned on the Be-42 search and rescue variant. Onboard systems to lift rescued people out of the water include two LPS-6 six-seat semirigid motor boats, mechanized ladders, and special equipment. The maritime rescue craft is equipped with radar and navigation equipment permitting it to conduct rescue work in conditions of limited visibility, even in fog, and also at night. When extinguishing fires, the Albatros is capable of collecting water onboard while gliding, which permits it to increase the frequency of sorties to the site of a fire.

The maximum combat payload of 6,500 kg includes up to three Orlan antiship torpedoes or up to four to six Korshun, Yastreb, or Orel antiship guided missiles (all in the bomb bay).

#### Specifications of the A-40

Dimensions:	
Wingspan	42.00 m
Aircraft length without the pitot tube	42.00 m
Aircraft height (on a dry ramp)	11.00 m
Span of the stabilizer	11.87 m
Number of passengers	
In the passenger variant	105 people
In cargo-passenger variant I	37 people
In cargo-passenger variant II	70 people
Number of rescued people in the Be-42 search and rescue variant	34 people
Crew:	
Flight	5 people
Rescue team in the Be-42 search and rescue variant	4-6 people
Engines:	
Number and type	2 Perm MKB [Machine-Building Design Bureau] D-30KVP turbojet bypass engines
Static thrust	2 x 147.1 kN (2 x 15,000 kg)
Weights and payload:	
Maximum take-off weight in the civilian variant	86,000 kg
Maximum take-off weight in the ASW variant	90,000 kg
Maximum commercial payload	10,000 kg
Maximum combat payload	6,500 kg
Maximum payload in the firefighting variant (fire extinguishing mixture)	30 tonnes

Specifications of the A-40 (Continued)	
Flight data:	
Maximum cruising speed	800 kph
Patrolling speed	320-400 kph
Maximum flight range	5,500 km
Flight range with receipt of 15 victims (Be-42)	5,000 km
Flight range with a 6.5 tonne payload	4,700 km
Flight range with maximum commercial payload	10 tonnes (as published)
Flight range in the passenger variant	4,000 km
Flight range in the cargo-passenger variant	4,200 km
Required airfield runway length	1,800 m
Required length of water area	3,200 m
Required take-off run from an airfield	1,000-1,200 m
Required landing run at an airfield	700-900 m
Seaworthiness (height of wave)	up to 2.2 m

A full-size mockup of the Yamal light amphibious aircraft developed by the Aviaspetstrans Consortium jointly with EMZ imeni V.M. Myasishchev was demonstrated at "Mosacrosow-92." The amphibious aircraft is designed for operation in Russia's northern areas, Siberia, and the Far East. The preliminary design has been completed and production of a prototype aircraft has begun. The first flying model of the Yamal should take off at the end of 1994. It is planned to produce 20 aircraft by 1995. The assumption is that hundreds of these aircraft will be required.

More than 1 million pieces of various equipment are concentrated in the areas of the Russian North, but only 2-3% of the fleet has been adapted for operation under extreme conditions. In contrast to the summer period, the productivity of machinery and mechanisms is reduced by several times during the winter period under conditions of low temperatures. The design of the airframe, placement of the engines and propellers, and configuration of the equipment have been subordinated to the main goal—servicing the aircraft "from within" the fuselage, which is extremely important in the North.

Aviaspetstrans Consortium was formed around the Yamal project in 1990 to renew and develop the air service infrastructure on local routes in areas of the North, Siberia, and the Far East. Aviaspetstrans' task includes supplying economic organizations and the native population with modern aviation services with the maximum possible level of ecological cleanliness. The consortium consists of EMZ

imeni V.M. Myasishchev, several NII's [scientific research institutes], Moscow Regional Commercial Bank, and several state organizations.

Yamal is differentiated by its original twin-engine turboshaft power plant, consisting of two TVD-1500's and located behind the wing with a drive to the six-bladed pusher propeller installed on the T-shaped tail fairing. That location of the air propeller and also the air intakes located on top of the fuselage will protect the engines and air propeller from jets of water coming out of the amphibious aircraft's "chines" and underwing floats and from pieces of ice breaking off. Negotiations are occurring with Canadair on possible cooperation: They propose series production in Russia of the Canadair CL-415 twin-engine amphibious aircraft and joint work on Yamal. Pratt & Whitney Canada has offered four PT6 engines free of charge for installation on prototype Yamal aircraft.

#### Specifications of the Yamal Amphibious Aircraft

<b>Dimensions:</b>	
Wingspan	20.0 m
Aircraft length	15.3 m
Aircraft height	5.5 m
Wing area	41.0 m <sup>2</sup>
Size of the passenger salon	23.4 m <sup>3</sup>
Crew	2 people
<b>Engines:</b>	
Number and type	2 turbojet engines
Output	2 x 1,300 horsepower
<b>Weights and payloads:</b>	
Maximum take-off weight	7,200 kg
Maximum commercial payload with a 500 km flight range	2,000 kg or 18 passengers
With a 3,000 km flight range	500 kg
<b>Flight data:</b>	
Maximum cruising speed	450 kph
Minimum operating flight altitude (for ice reconnaissance, etc.)	100 m
Maximum operating flight altitude	6,000 m
Take-off distance from the water	230 m
Take-off distance from the ground	225 m

Nizhniy Novgorod's AeroRIK Scientific Production Enterprise reported on the Dingo multimission amphibious aircraft with a hydrofoil undercarriage that is being developed.

#### Specifications of the Dingo Amphibious Aircraft

Wingspan	14.5 m
Aircraft length	12.5 m
Aircraft height	3.5 m
<b>Power plant:</b>	
Sustainer engine	Turbojet engine
Output	850 horsepower
Lift engine to create the air cushion	TVA-200 gas-turbine engine
Output	250 horsepower
Take-off weight	3,600 kg
Full payload	850 kg
Maximum speed	350 kph
Cruising speed	250 kph
<b>Flight range:</b>	
Maximum	1,300 km
With an 850 kg payload	850 km

### 5. Remotely Piloted Vehicles

The development of remotely piloted vehicles (RPV) capable of accomplishing a wide circle of missions on behalf of the various branches of the armed forces and the national economy is one of the most promising directions of development of military and civilian aircraft.

The Kulon NII and the Russian Air Force demonstrated the Malakhit terrain aerial surveillance system designed for surveillance in the optical and IR range at any time of day using the Shmel-1 RPV.

Typical missions for the system are: ecological monitoring of the environment; patrolling terrain; monitoring the radiation situation around AES's [nuclear power plants]; surveillance of the state of oil and gas pipelines, heat and energy lines; assessment of the state of ice on rivers, and the consequences of natural disasters (earthquakes, fires, floods, etc.); monitoring the accomplishment of agricultural work; assessment of the moisture content of the soil, the temperature of fields, weed levels, and the state and quality of sowing; and surveillance of herds and the migration of animals.

The system consists of an integrated launch and control unit located on a BMD-1 combat assault vehicle tracked chassis, the RPV, and a mobile maintenance facility.

The launch and control unit carries out automatic pre-launch monitoring, launch, and command and control of the RPV, and reception and depiction of terrain images

on a television screen in real time. A picture of the terrain that is being observed from onboard the RPV and also the track of the aircraft and its current coordinates are depicted on a video control device installed on the control and launch unit.

A high degree of automation of the processes of monitoring ground and onboard devices and also flight control and the availability of built-in simulator systems permit reduction of the requirements for operator qualification and reduce operator training time.

The system ensures command and control and reception of information from the RPV when located at a distance of 60 km from the launch and control unit. Simultaneous command and control of two RPV's is permitted. A television camera installed on the RPV has an adjustable remotely controlled angle (3-30°), the IR sensor field of view totals 3.4 of the flight altitude, and the resolution of the IR sensor is 3 mrad.

The Shmel-1 RPV is a reusable aircraft manufactured according to a normal aerodynamic design with a pusher propeller in a ring shroud. An autopilot ensures stability of flight, which consists of a computer, compass, vertical gyroscope, angular velocity sensors and electric drives to control the ailerons and elevators and also the throttle butterfly of the sustainer engine.

#### Specifications of the Shmel-1 RPV

Take-off weight	130 kg
Engine type	piston
Engine output	23.9 kWt
Range of flight operating altitudes	100-3,000 m
Flight speed	140 kph
Flight duration	2 hours
Landing system	parachute

A model of the future Kolibri RPV developed at the OKB imeni A.S. Yakovlev was demonstrated in the spring of 1992 at the African Air Show in Johannesburg (Republic of South Africa). The aircraft, manufactured based on a normal aerodynamic design, has a wing that smoothly joins the fuselage, which promotes reduction of the radar signature, and a T-shaped tail to which a pusher propeller has been attached.

The RPV is equipped with a 75 horsepower piston engine, can carry a payload that consists of various sensors with a total weight of 70 kg, and is capable of operating at a distance of up to 180 km from the launch and control unit. The combat radius can be increased to 700 km when a second relay RPV is used.

**Specifications of the Kolibri RPV**

Wingspan	5.90 m
RPV length	4.25 m
Span of the horizontal tail	1.70 m
Take-off weight	280 kg
Fuel weight	72 kg
Payload weight	70 kg
Engine type	piston
Engine output	75 horsepower
Range of flight operating altitudes	50-3,500 m
<b>Maximum operating radius:</b>	
Without using a relay RPV	180 km
Using a relay RPV	700 km
Flight duration	8 hours
Flight speed	250 kph

Raduga MKB offered information on a series of small agricultural and military RPV's. In particular, an autogyro was demonstrated that utilized the Shmel RPV fuselage in its design. Another small aircraft-type flying apparatus that is designed for use in agriculture is launched and controlled from a small launch and control unit that is mounted on a GAZ-66 motor vehicle chassis.

Eniks NITs demonstrated the Ye85 aerial target, designed to imitate cruise missile and glide bomb type targets, at "Mosaeroshow-92". The target has been manufactured according to a normal aerodynamic design with a straight wing, has light plastic construction, is launched from a helicopter's external hard point and carries out a landing on a parachute. Programmed or radio-command target control is used. Employment of a light original design pulsing VRD [jet engine] that is protected by a copyright is a distinguishing feature and the thrust of the PuVRD is approximately 40 kg.

**Specifications of the Ye85 Target**

Launch weight	120 kg
Flight speed	250-600 kph
Flight altitudes	200-3,000 m
Range	70 km
Radar cross signature	0.1-10 m <sup>2</sup>

The conclusion of the RUSSIAN "MOSAEROSHOW-92" AEROSPACE EXHIBITION survey is in No. 42.

**PHYSICS****New Theory Explains Anomalous Properties of Water**

Having studied the properties of water, S. Benson and E. Siebert (University of Southern California at Los

Angeles) have arrived at the conclusion that the molecules of this liquid do not jostle randomly, but form short-lived networks in the shape of cubes of eight molecules and rings of four molecules. The cubes and rings are then formed into chains and networks.

Experimental data obtained for the hard and gas phases were used to construct a theoretical model of water in the liquid phase. The chemists claim that the microstructures they discovered help explain some of the unusual properties of water, such as its ability to absorb large amounts of heat and its ability to expand on freezing.

Most liquids fall into one of two categories: they are either regular or structured. The molecules in regular liquids form relatively weak bonds in pairs under the impact of van der Waals forces. Because these forces do not have a particular direction, the molecules are free to adopt any orientation relative to one another to fill free space. The organic solvent tetrachloromethane is an example of such a liquid. Such liquids, the molecules of which are held together by stronger, oriented forces, are among the regular liquids. Usually, these are hydrogen bonds, which form between a slightly positive hydrogen atom in one molecule and an oxygen atom with a weak negative charge in a neighboring molecule.

Structured liquids cannot be described by the simple empirical formulas that are used to describe the physical properties of regular liquids. For example, each molecule in a regular liquid with closely packed molecules can be surrounded by 10-11 others. In a structured liquid, there can be as few as 4-5 of these molecules and therefore sufficient free space remains between molecules.

The American scientists think that water is possibly the most extreme representative of a structured liquid. It has maximum density at a temperature of 4°C and an unexpectedly high heat capacity. After many years of debates, scientists arrived at the conclusion that hydrogen bonds are the cause of the anomalous properties of water, however, there is still no adequate theory that precisely predicts water's heat capacity and fluidity or explains such a property of water as its low density in solid state.

Benson and Siebert claim that with their new octamer-tetramer model of intermolecular hydrogen bonds permits them to predict the physical characteristics of water in the entire range of temperatures of the existence of the liquid phase (from 0 to 100°C) with an accuracy of up to 2% with regard to experimental data.

The scientists do not claim that water consists exclusively of cubic and ring bonds of molecules, but they think that these are the simplest and most widespread types of bonds. Instruments do not yet exist that permit us to record such formations because the hydrogen bonds between water molecules form and break with a frequency of 500 Ghz.

Benson and Siebert say that water might also contain other structures—such as cyclic pentamers (five molecules in a ring) or decameric sandwich dimers. But they also admit that there is no evidence of the existence of these microstructures, except for calculations of thermal and volumetric properties which match experimental data.

The proposed microstructural theory also explains water's anomalous behavior when other substances are added. Although the presence of simple hydrogen bonds predicts that a polar substance such as ammonia gives off heat when it dissolves in water, it cannot explain why this occurs even when nonpolar tetrachloromethane dissolves.

*NEW SCIENTIST*, 25 July 1992, Vol. 135, No. 1831, p. 14.

### Berlin Builds a Second Synchrotron

The Federal Ministry of Research and Technology (Germany) has announced the construction of a second synchrotron, BESSY-II, in Berlin-Allershof in addition to BESSY-I located in West Berlin.

BESSY-II is primarily designed for basic research and will have a ring with a diameter three times as large as BESSY-I's, which will permit the production of a magnetic field with approximately 1,000-10,000 times greater voltage.

Construction of the new synchrotron will cost 190 million Deutsche marks (£68.5 million). The money will be allocated by the German Federal Government and the Berlin authorities.

*NEW SCIENTIST*, 1 August 1992, Vol. 135, No. 1832, p. 10.

## CHEMISTRY

### Boron Molecules that Look Like Fullerenes

In 1976 Harvard Chemist W.N. Lipscomb had already predicted the possibility of the similarity of the structures of a  $B_{32}H_{32}$  molecule and a multi-atom carbon molecule with the Formula  $C_{60}$ . The shape of the 20-sided  $B_{32}H_{32}$  molecule is similar to the ball-shaped  $C_{60}$  molecule [the buckyball].

Lipscomb and his colleague L. Massa (New York's Hunter College) conducted a systematic study of the possible correspondence between boron compounds and fullerenes—the new class of carbon molecules that include  $C_{60}$ .

In the boron hydrides, the boron atoms bond to each other to form a particular shape and the hydrogen atoms radiate from the cages formed by the boron atoms. Superimposing the two molecules, the 60 carbon atoms on the boron hydride molecules match up with the hydride molecule's 60 faces, while each of the 32 boron atoms would fall smack in the middle of the faces formed by the carbon atoms.

You can calculate the number of matches using the Descartes-Euler formula, which describes the fit between the two types of molecules by summing the number of faces and the number of atoms in the vertices (less two). In closed geometrical structures, contacts represent the connecting lines between vertices; in molecules—they represent the shortest distances between neighboring atoms.

Like fullerenes, hollow boron molecules should have new useful properties. Lipscomb and Massa suggest chemists try to make closed boron hydrides using laser beams to vaporize a calcium boron compound in the presence of hydrogen.

*SCIENCE NEWS*, 20 June 1992, Vol. 141, No. 25, p. 406.

## COMPUTER EQUIPMENT

### IBM and Hewlett-Packard Innovations

On 21 September IBM and Hewlett-Packard planned to report, independently of each other, on the production of new high-performance personal computers to increase their share of the sales market.

IBM Corporation, the largest manufacturer of computers in the world, will demonstrate a number of its PS/2 series PC's with a three-year service guarantee in New York which it plans to promote as computers for commercial users. And in the beginning of September, IBM reported on the production of a new cheap PS/1 series system that is designed for use in small offices and under everyday conditions.

Five new table-top systems, three servers, three monitors, and four personal computers with audio and video capabilities are in the PS/2 series. The firm's OS/2 version 2.0 operating system will be loaded in all of the systems beforehand and all of them will be based on IBM's "microchannel" architecture. An IBM spokesman refused to provide any detailed description of the product whatsoever. Personal Computer Company, a new IBM subsidiary enterprise with headquarters in Somers (New York), will be involved in marketing the expanded PS/2 series.

According to information from IBM spokesmen, the firm's income from production of PC's totaled \$7 billion in 1991, however, IBM's "Personal Business" Division head J. Canavino refused to provide a prediction for next year.

Hewlett-Packard plans to offer four high-class personal computers, manufactured based on the 80486 microprocessor, with a starting price of \$1,149. Hewlett-Packard, whose income totaled \$14.5 billion in 1991, is known primarily as a manufacturer of printers, automated work stations, and measurement equipment. According to expert assessments, printers account for 25% of the company's profits and personal computers only account for 5%.

In August, Hewlett-Packard reduced prices on its personal computers by more than 25% while attempting to remain competitive in the market. According to the company's official statement, the new series of computers, which have received the name Vectra 486N PC, are \$400 cheaper than comparable items from Compaq Computer Company.

*New York (Reuters), 3 September 1992; 24 September 1992.*

### **Cray Receives Contract from NASA**

Cray Research has received a NASA contract worth \$74 million for the delivery of a high-speed computer, beating out such competitors as Japan's NEC Corp. and its American marketing partner Control Data Systems.

The computer is needed by NASA experts from Ames Scientific Research Center (Mountain View, California) to assist in the design and conduct of tests of new design aircraft and spacecraft. This center became the first to utilize numerical modeling on a computer to replace certain expensive and time-consuming tests of models of aircraft in a wind tunnel.

Hundreds of scientists from government, industrial, and scientific organizations utilize the computer installed at Ames Scientific Research Center in their work.

Cray received a seven year contract. The order for the computer that was issued by Ames Scientific Research Center became the first joint marketing effort between Control Data Systems and NEC after they signed a cooperation agreement in January 1992.

Control Data Systems (Arden Hills) became the successor of Control Data (currently Seridien) for conducting calculations on a computer.

NASA awarded the contract to the American firm in response to NEC's efforts to introduce high-speed computers in the American government market, in which Cray is the leader. Having received at one time a Canadian Meteorological Service contract, beating out Cray in the process, NEC filed suit against NASA in Federal Court, accusing the agency of a pro-American policy, and won the right to compete in the competition along with Cray.

According to NASA spokesmen, Cray won the contract thanks to the superiority of the specifications of its new C-90 computer and the firm's reputation as a long-standing, reliable, and profitable partner. The C-90 computer will replace the Cray-2 computer, which has been utilized at the Ames Scientific Research Center since 1985.

Cray made a profit in the amount of \$113 million with income of \$862.5 million in 1991.

*AP, 3 September 1992.*

## **POWER ENGINEERING**

### **Prospects for Solar Power Engineering in Japan**

Solar batteries, the energy of which is being used to operate air conditioners, have been installed in a building at Sanyo Electric enterprise (Island of Avadzi [transliterated], Western Japan).

Utilization of solar energy as an ecologically clean source is becoming increasingly attractive as a result of growing alarm due to the harmful aftereffects for the planet's ecology of the combustion of fossil fuels. The volume of world production of solar batteries have dramatically increased recently, although their share in the overall production of energy remains quite insignificant. The total output of solar batteries in 1991 increased to 55 MVt (which is equivalent to the output of a small generator plant), in contrast to practically zero in 1977.

Japan's share in world production of solar batteries has increased in the last several years and totaled 36% in 1991. The U.S.' share totals 30% and the EEC countries' share is 24%.

So far, solar batteries have been employed in a quite limited assortment of items. They are primarily used in calculators and watches, devices with low energy consumption, and the utilization of solar batteries in them was dictated by convenience rather than economic or ecological considerations.

The main problem preventing the broader introduction of solar batteries is their high cost. Although the installation of solar batteries permits a dramatic reduction of expenditures for electrical energy, the user must initially spend 1.5 million yen (\$12,000) on that system.

Sanyo is cooperating with Misawa Homes design home-building company in the construction of homes equipped with solar batteries. According to the calculations of Sanyo experts, expenditures on the installation of solar batteries in the amount of 6 million yen (\$49,000) will be recouped in just 10 years. They need to increase the batteries' efficiency (depending on the type of element) and reduce their cost in order to expand the sales market for these batteries.

Elements produced by Kiosera, the second largest manufacturer of solar batteries, based on semicrystallized silica, have the greatest efficiency (16%). These elements are expensive to produce (the energy expended in their manufacture is recovered in two years) and must be subjected to temperatures of 1,500°C in the manufacturing process.

Sanyo's elements are made from amorphous silica and are more efficient: A temperature of approximately 300°C is required for their manufacture, the energy transformation coefficient is more than 10%, and the expended energy is recovered within a year. Sanyo stated that expenditures for the production of elements made

from amorphous silica do not exceed \$5 per kVt. Expenditures should significantly decrease in mass production: up to \$1 per kVt by the year 2000, based on the firm's plans.

Firms that manufacture solar batteries hope to expand their sphere of employment—from autonomous devices like outside spotlights, which are recharged during the day for operation at night, to electromobiles with hybrid engines, to building electrical supplies.

Looking to the future, Sanyo experts have promoted Project GENESIS (a global energy network based on solar batteries and international superconductor transmission lines), in accordance with which deserts in various countries of the world will be covered by a network of solar stations, the energy of which will flow into populated areas through a network of superconducting cables. So far, implementation of this project is impossible due to economic considerations, however, the situation will change with time.

*SUMOTO (Reuters), 14 September 1992.*

## NEW TECHNOLOGIES

### Processing Explosives into Fertilizers

Germany Army specialists have decided to process 20,000 tonnes of explosives into fertilizers. The explosives were used in mortar and missile rounds that were inherited from the army of the former GDR.

The explosives (nitrocellulose, nitroglycerine, and dinitrotoluene) will be subjected to microbiological processing and transformed into fertilizers. The mortar rounds are being dismantled at the Spreewerk Luebben plant located southeast of Berlin. The explosives are placed in a solution and "cooked" by chemical hydrolysis, a process that renders the solution nonexplosive and reduces the material to microbe-sized morsels. Dinitrotoluene is additionally "cooked" by alkali fusion at high temperature to break down toxic anilines that are a component of this explosive.

Later the solution, a mixture of cellulose, glycerol, and nitric acid, undergoes microbiological processing. A. Dahn, a spokesman for Berlin's BS Engineering and Contracting, which developed the explosives scrapping process, says the bacteria can be found in processed water from treatment plants. A sludge containing ammonium nitrate which can be dried, composted, and used to fertilize the soil remains as a result of the explosives processing process.

Although processing explosives is not the simplest and cheapest technology to produce fertilizers, it may prove to be the best way to dispose of explosives in Germany. Combustion of the explosives in furnaces is practically unacceptable because it would take approximately five years just to obtain the license for this technology. And even if the incinerator's technical specifications meet the

standards, the cost of just the stack scrubbers alone would total approximately 75 million marks (£25 million).

In Dahn's words, £1.5 million were required to develop the explosives microbiological scrapping process, and initiating the experiments and construction of the explosives scrapping plant on an industrial scale will require another £4.7 million. He estimates the plant will be able to process the entire stockpile of explosives in five to 10 years.

*NEW SCIENTIST, 8 August 1992, Vol. 135, No. 1833, p. 9.*

### Tire Scrapping Technology

Britain's AEA Technology has developed a cheap technology to process old automobile tires into gas, oil, and other products. The technology is based on the separation of tire materials under the impact of high temperature. The developers say that this technology is cleaner and more economical than scrapping tires through incineration.

A pilot plant has been tested at an AEA Technology test site near London. Tires are heated up to 1,080°C in a kiln and, in the process, two fuels, gas and oil, a substance rich in high-quality carbon, and steel were separated. The kiln is equipped with a condenser to recover oils and with a gas scrubber.

AEA Technology sold the first commercial MPD (Multi-Purpose Disposer) plant to an American firm that will manufacture and sell the plant in North America.

Each plant that operates based upon the new technology can handle 1,000 kg of tires in less than nine hours. Two hundred [as published] plants can be linked up to annually process 14,000 tonnes. Each tonne of European-produced tires produces up to 220 kg of aromatic oils, 240 kg of gas, 420 kg of carbon, and 160 kg of steel.

The carbon-containing element that is formed when the tires are scrapped is of sufficiently high quality and calorific value that it can be used either in filters or as a fuel. The oil and gas can be pumped straight into nearby thermal electric plants using pipelines.

Its developers state that the MPD system meets all of the clean air standards that have been adopted in the countries of Europe at the present time and could be licensed in any state of the United States, except California, where clean air standards surpass world standards at the present time. The unit requires relatively simple refinements to meet those standards.

*NEW SCIENTIST, 29 August 1992, Vol. 135, No. 1836, p. 21.*

### Electricity Extinguishes Fires

Israeli experts from Ben-Gurion University (Beer-Sheva) have developed a fire extinguishing device, the principle of operation of which is based on the phenomenon of so-called electric wind that is capable of putting out any flame on a flat surface, for example, a rug or a pool of

burning oil. The device has a diameter of one meter and does not have a harmful impact on the environment because the use of water, foam, or Halon gas are not required for its operation.

The device consists of two electrodes—a flat electrode and a sharp electrode. When voltage is applied to them, an electrical field is formed, which is much more dense near the sharp electrode. If the field is large enough, atoms near the sharp electrode lose electrons which are transformed into positively-charged ions and, propelled by the field, move away from the sharp electrode, in the process interacting with other, neutral atoms. This movement of atoms and positive ions is called electric wind.

Israeli experts searched for the optimal shape and orientation of the sharp electrode to use electric wind to blow out fires. The flat burning surface acts as the other electrode. A meter-long wire attached to a metal frame and connected to a direct current source was utilized as the first electrode.

A flame is blown out when the wire is moved by hand over the fire at a height of less than 10 cm from the surface at a rate of approximately one meter per second. The electric wind separates the flames from the burning material and rapidly cools the material below its ignition temperature.

The developers say that the fire extinguishing device should be very cheap because it is manufactured from simple components and has low energy consumption.

Tel-Aviv's Spectronix is developing a commercial version of the device. It is possible that production of the new device will begin in several months.

*NEW SCIENTIST*, 15 August 1992, Vol. 135, No. 1834, p. 20.

## INSTRUMENT BUILDING

### Shortcomings of Atomic Microscope

We obtain a depiction of the structure of the landscape of a material in an atomic microscope based on the forces of interaction between atoms in a microprobe and the material under investigation. However, Swiss scientists warn that imperfections in the tips can lead to spurious results.

In the 1 June *APPLIED PHYSICS LETTERS* a case of an atomic microscope misrepresenting the topography of a diamond film is described. Examinations with a scanning electron microscope and a scanning tunneling microscope revealed that the film surface consists of sharp facets and edges formed by oriented crystals. The atomic microscope presented this surface in the shape of truncated pyramids, and the microprobe's tip had that same squared-off shape.

Microprobe tips are etched in batches from silicon wafers. The scientists found three flawed tips in a batch

of 10. Dust or imperfect processing technology could have been the cause of the flaws. Scientists see the solution to the situation in scientists calibrating the tips before beginning experiments.

*SCIENCE NEWS*, 13 June 1992, No. 24, p. 399.

### VIPER Explosives Detector

I. Cambridge (a division of Meggitt Control) is offering the VIPER (Vapor Intensifier for Plastic Explosive Recognition) portable explosives detector that permits the detection of particles and vapors of plastic explosives.

Detection of plastic explosives is a difficult task due to the low pressure of the vapors emitted by them. However, a trace of explosive is adequate for the VIPER detector and therefore it can be utilized to detect such explosives as hexogen, PETN, and semtex, and also the more broadly used trinitrotoluene and dynamite. The instrument is easy to use. Collection of samples can be done using a vacuum technique or by wiping a surface with a special cloth. Samples taken for the content of both vapors and also particles of explosives are processed identically and are placed in an analyzer.

The VIPER detector has already undergone testing at the Lima Peru airport, where it was used to inspect the baggage of all passengers of three international American airlines for three days. Security forces managed to completely inspect approximately 1,000 items for explosives content thanks to the detector's rapid operation (no more than three seconds) and operation in real time with a low probability of false alarm.

*INTERSEC*, July-August 1992, Vol. 2, No. 3, p. 103.

## AUTOMOBILE MAKING

### Mitsubishi's New 3000GT Automobile

Japan's Mitsubishi has manufactured a new model of the 3000GT automobile, to which the definition of "leading technology" has been totally applied. This is an all-wheel drive automobile with a V-shaped twin-engine with a turbocharger, an antilock braking system, electronically controlled suspension, and an aerodynamic shape that can be adjusted depending on speed. Comfort, safety, and ease of driving is ensured thanks to the use of all of the systems listed above.

The new automobile is capable of reaching speeds of up to 250 kph and can accelerate from 0-100 kph in 5.9 seconds. This automobile demonstrated the capability to move at a speed of 56 kph in fifth gear in anticipation of the moment when road conditions would permit it to reach normal speed on the heavily traveled roads of Bedfordshire and Hertfordshire.

The engine operates quietly with the drive shaft at more than 1,000 rpm and a speed of 48 kph and emits a melodic hum when shifted into the upper gears at 6,000

rpm and higher. The Mitsubishi 3000GT has surprisingly low road noise for an automobile with 17-inch (432 mm) wheels and very low-placed tires (SP 8060 tires specially developed for the sports car by Dunlop).

The automobile is equipped with an air conditioner and driver-side air bag. The rear seats play an auxiliary role and do not provide adequate comfort; the rear portion of the coupe is designed more for storing baggage, for which the rear hatch can be raised.

The Mitsubishi 3000GT is being offered in a four-seat variant for £35,500, which is £20,000 cheaper than Honda's NS-X two-seat model of that same class and nearly £4,000 cheaper than a Porsche-968. However, the Mitsubishi 3000GT is more expensive than Nissan's 300ZX (£32,775) and the just produced Subaru SVX model (£27,996).

One hundred 3000GT automobiles will be shipped to Great Britain in 1992 and orders have been received for more than half of the shipment.

The English market for sports cars and coupe models with high specifications went down from 11,100 vehicles in 1990 to 7,481 vehicles in 1991. A total of 2,965 vehicles of that type were sold during the first half of 1992. Experts think that the overall economic decline, increased insurance payments, and also the stricter actions of law enforcement agencies with regard to individuals who exceed the speed limit is the cause of the decline in demand.

*FINANCIAL TIMES, 1 August 1992, p. VIII.*

### **Sale of Allison Transmission**

General Motors has decided to sell its Allison Transmission subsidiary, which specialized in the production of transmissions for heavy trucks, to the West German company ZF Friedrichshafen. The deal must be approved by the governments of both interested parties and, according to plans, will enter into force at the end of 1992. Details of the agreement are not being released. According to General Motors Vice President L. Royce, his firm will continue to count on deliveries from Allison Transmission.

The ZF Plant, with headquarters in Friedrichshafen, is valued at \$4 billion and specializes in deliveries of transmissions, suspensions, and control devices to the world market. Acquisition of the Allison Transmission subsidiary will assist ZF to develop a long-term strategy for the production of world-class power plants for a wide circle of purchasers throughout the world.

An official ZF spokesman said that the German company plans to retain Allison's leadership and staff of workers (approximately 5,000 people) and will continue production of automatic transmissions for trucks, buses, off-road vehicles, and military vehicles in Indianapolis.

Thirty three thousand people in 49 of the world's countries work at ZF plants and the company made an annual income of \$3.8 billion in 1991.

General Motors is offering another subsidiary for sale in Indianapolis—Allison Gas Turbine—however, a purchaser has not yet been found. The activities of Allison Gas Turbine depended primarily on military contracts, but this subsidiary has been increasingly oriented toward the civilian market in the last several years. Allison Gas Turbine develops aircraft engines for new aircraft that are being operated on regional airlines and also for personal business aircraft, that is, it specializes in a sphere where obtaining profits is only possible after several years.

General Motors has already informed the personnel of Allison Gas Turbine about the shutdown of production.

*AP, 5 August 1992.*

### **Robot To Replace Oil in Automobile Engine**

On 16 September, the Japanese firm Idemitsu Kosan began to sell an innovation for automobile owners—the Oiru Robo device for automatic replacement of oil in an automobile engine.

The entire operation is carried out in three steps, and the participation of an individual ends at the first stage when the "on" button is pushed. After that, the "oil robot" pumps the old oil out of the vehicle and pumps in exactly the same amount of new oil. Replacement of 3.5 liters of oil takes five minutes. Utilization of the new device will permit a reduction of one-third in the time a client needs to stay at a gas station where these types of services are offered.

*ITAR-TASS, 19 September 1992.*

## **NEW MATERIALS**

### **Solid, Lighter Than Air Material**

A team of American scientists from Livermore National Laboratory (California) under the leadership of R. Morrison have invented the new porous material Seagel with such a low density that the scientists' say it would float away if it were not weighed down by the air trapped in its microscopic pores.

Seagel, which is biodegradable, was obtained by processing agar, a component of brown algae [kelp] that is widely used as a thickener during the preparation of food items such as ice cream. Its developers say that Seagel is also suitable for food and only carbon dioxide and water are formed during its combustion.

To obtain Seagel, agar is first dissolved in water and then an organic solvent and an emulsifying agent are added to the mixture which disperses the agar evenly throughout the liquid as tiny droplets. The liquid then sets into a gel and is freeze-dried to obtain the final product.

Depending on the conditions of the process and the concentration of the initial products, you can obtain a material with different properties depending on the individual application: from packaging materials to slow-release capsules for medicines.

Seagel should find the greatest application with a density of 40-50 mg/cm<sup>3</sup>. This compares with the 60 mg/cm<sup>3</sup> density of balsa wood, which is widely used as an insulating material in supertankers and as a noise-absorbing material in high-speed trains. Seagel can also replace polyurethane and polystyrene styrofoam, however, you need to take into account that the material must be hermetically sealed because it dissolves in water at a temperature of approximately 50°C. However, even this property can be useful if Seagel is used as a mold for casting because it permits it to be easily washed away to reveal the finished product.

*NEW SCIENTIST*, 15 August 1992, Vol. 135, No. 1834, p. 19.

## ECONOMICS

### Japan Proposes Scientific Research Effectiveness Criteria

Japan is still inadequately allocating resources for scientific research in contrast to other industrially developed countries, despite the enormous growth of appropriations in this sphere over the last two decades. The Ministry of Foreign Trade and Industry, which sets the direction of the country's economic development, highlighted this problem in the latest issue of a White Paper, suggesting the introduction of the indicator Technostock as a yardstick for scientific research results.

Technostock is the total amount spent on research and development taking into consideration the obsolescence factor. To calculate Technostock, R&D expenditures are multiplied by the Technoflow factor, the amount of which is lower than one and depends on the time required to introduce new technology. Technoflow is added to Technostock for the previous year, taken also with the obsolescence factor, and the resulting sum is the Technostock for that year.

There are two kinds of Technostock: the first calculates expenditures for production and profits and the second—so-called intellectual property.

Japan has been rapidly catching up with the United States in production-directed Technostock. For the period 1970-1988, this indicator increased by 608% in Japan and by a total of 10.8% in the United States, although in 1970 the United States had 31 times as much production-directed Technostock as Japan. In 1988, the gap had narrowed to 4.8. Japan's intellectual property indicator rose 320% and that of the U.S.—50%—for the period indicated. The gap between the countries narrowed from 15:1 in favor of the United States in 1970 to 5:1 in 1988. In the process, the gap in total GNP between

Japan and the United States has been closing even faster. In 1988, the GNP of the United States was only 1.7 times that of Japan.

Japan lags behind not only the United States but also Great Britain, France, and Germany in the intellectual property indicator and in the number of published scientific papers. Only R&D expenditures and the number of patents applied for in other countries were growing in line with GNP.

The White Paper recommends strengthening basic scientific research while considering the results of a poll taken among university and public officials that suggested assigning priority to work in the areas of the ecology and energy-saving technologies.

*NEW SCIENTIST*, 29 August 1992, Vol. 135, No. 1836, p. 8.

### Expenditures on Space Programs

The cost of civilian space exploration being carried out by approximately 25 countries and international organizations is assessed at \$25 billion today. According to data in SPACE NEWS, the United States, France, Japan, and China alone are annually spending more than \$1 billion on these needs.

NASA, with an annual budget of \$14.7 billion which is spent primarily on spacecraft, surveillance satellites, and the development of the Freedom Space Station, remains the main space exploration center. NASA's main partner on the continent is Canada (\$292 million). Brazil annually allocates \$100 million for the launch of satellites and Argentina—\$10 million for the launch of satellites to conduct astronomical exploration.

France, which spends \$1.38 billion per year, leads on the European Continent. Italy (\$973.4 million), Germany (\$969 million), and Great Britain (\$206.6 million) follow. According to official data, Russia allocates \$741 million per year on space programs.

In Asia, the space budget of two countries exceeds a billion dollars. They are Japan (\$1.262 billion) and China (\$1.2 billion). China spends its resources primarily on launches, for communications satellites and for meteorological satellites. India, Taiwan, South Korea, and Pakistan also participate in this activity.

Australia allocates \$13 million per year for space exploration. Only the RSA [Republic of South Africa] is represented in space from countries on the African Continent.

The European Space Agency (ESA), with a budget of \$3 billion per year consisting of contributions from 14 European states, coordinates European space programs. Canada is an associate member of ESA, and ESA, in turn, is participating in the development of the Freedom Space Station with a 10% share.

*Washington (AFP)*, 2 September 1992.

### **Germany Increases Amount of Financing for Scientific Research**

Germany's Ministry of Research and Technology has a 3.55 billion budget for this year, or more than a 3.8% increase as compared to the 1991 level. A large part of the allocated resources is earmarked for eastern Germany. In 1993, £627 million or 18% of the science budget will be invested to build up research on the territory of the former GDR, which signifies an increase in appropriations of 9.8% compared to the 1992 level. Approximately £100 million from this amount is being designated for universities.

The increase in financing comes in the wake of reports by government and private agencies that the quality of research in eastern Germany still lags far behind.

Research into climate, ecology, and public health won the largest increases in funding. The Ministry of Research and Technology has allocated £5.7 million for this purpose.

In its space strategy, Germany is shifting from large-scale manned flights toward unmanned flights and the expansion of sensing from space, and is conducting negotiations with the CIS countries about expanding cooperation in space research.

*NEW SCIENTIST*, 25 July 1992, Vol. 135, No. 1831, p. 4

### **Siemens and Philips Joint Ventures in Germany and China**

The EEC Commission intends to conduct a study of certain agreements between Siemens (Germany) and the German subsidiary of the Dutch firm Philips Electronics in accordance with the law on company mergers.

According to the Commission's data, documentation will be studied on the transfer of Philips cable plants in Köln and Nürnberg to its German joint venture with Siemens—Nachrichten kabel und Anlagen.

In December 1991, Philips reported negotiations on the transfer of its German and Dutch cable and optical fiber manufacturing enterprises to Siemens.

The EEC Commission task also includes studying Siemens' plans to repurchase from Philips half of the share in the Chinese firm Yangtze Optical Fiber and Cable Company. The remaining 50% of the capital belongs to Chinese organizations.

The EEC Commission intends to investigate Siemens' plans to increase its share in the German firm Norddeutsch Zeekabelwerke, which specializes in the production of cables and measurement equipment.

The EEC Commission has four weeks to ascertain if the Siemens and Philips agreement will inflict damage on the situation in the European Common Market. In the event serious doubts exist in the advisability of the deal, a more thorough four-month study of the state of affairs

will be conducted. The Commission has the right to change the terms and even block an agreement that lessens competition.

*Brussels (AP)*, 9 September 1992.

### **South Korea Finances Leading Technology Projects**

In the middle of August, South Korea's Ministry of Science and Technology announced the first projects proposed within the framework of government efforts directed at achieving the technological level of Japan and the leading Western countries by the beginning of the 21st century.

The government program, assessed at \$6 billion, is known as the G-7 project (seven is the number of countries that are at the level which South Korea intends to achieve. Besides Japan, they are the United States, Canada, France, Germany, Italy, and Great Britain). The South Korean Government plans to invest more than 2,400 billion won (790 won = \$1) into the project by 2001 matched by a similar amount from the country's industry.

The announced projects encompass three of the 14 scientific research areas (new pharmaceutical and agrochemical substances, new materials, and new functional biomaterials) and come under the jurisdiction of the Ministry of Science and Technology. Other projects, covering such areas as high-definition television, semiconductors, communications lines, and automated manufacturing systems, will be announced shortly by other ministries.

More than 20 government institutes, 50 universities, and 60 private companies will participate in the already announced projects. The Korea Institute of Science and Technology [KIST] and the Korea Research Institute of Chemical Technology [KRICT] will lead the research. The industrial firms participating include such conglomerates as Hyundai, Samsung, Daewoo, and also several pharmaceutical companies.

In 1992, the government and industrial firms allocated 27 billion won (\$34 million) to develop the three indicated research areas. Distribution of approximately half of these budget resources was cited in a table and more complete information will be published in several months (the data was expressed in millions of won).

Dozens of pharmaceutical companies and several universities will participate in research in the sphere of new medicines and vaccines, to which a large portion of budget resources has been allocated. Two nonprofit government-industry consortiums—the New Medicine Development Consortium and the Genetic Engineering Research Consortium—have been established.

Hyundai, Samsung, and Daewoo have supported research to develop new ceramic materials for use in the heavy industry, automobile, and electronic sectors. But

so far there is no sign of cooperation proposals from other countries, as the South Korean Government had hoped.

*NATURE*, 20 August 1992, Vol. 358, No. 6388, p. 613.

### R&D Expenditures in OECD Countries

The Organization of Economic Cooperation and Development (OECD), which includes 24 industrially developed countries, has published information on the organization's member-countries' expenditures for the conduct of scientific-research and experimental design work. The OECD has published this information for the first time, which provides the opportunity to conduct an accurate comparison of R&D expenditures in the United States, Japan, and the European Community countries.

Per capita R&D expenditures in the EC countries total \$310 per year, as compared to \$510 in Japan and \$600 in the United States. In the process, these expenditures account for 2% of Gross National Product in the EC countries, 2.9% in Japan, and 2.8% in the United States.

However, government appropriations for R&D in the EC countries cover 17.7% of total expenditures for this work, compared to 8% in Japan and 12.4% in the United States.

*NEW SCIENTIST*, 18 July 1992, Vol. 135, No. 1830, p. 11.

### Tax on Packaging

One of the most complex issues that manufacturers, ecological experts, and government organizations of the world's various countries face right now is the continuously growing amount of packaging materials that are used.

Until recently, the adoption of stricter decrees that provide for the government's increased role was proposed as the solution to this issue. These are legislative acts that oblige manufacturers to collect and reuse used packaging materials in increasingly large quantities and also attempt to establish quantitative indicators of the increase of the percentage of wastes that are reused. Decisions were also made to ban certain methods of destroying used packaging materials, such as burning them.

The social and economic research center in the sphere of global ecology thinks that using market laws is the most effective method to resolve the problem. Center experts think that we need to create conditions so that the minimum possible amount of material is used during the manufacture of packaging and introduce economic incentives to intensify the collection and processing of used packaging we must do.

The introduction of a progressive tax on packaging materials, the amount of which would depend on the degree of danger this type of packaging poses for the

environment, is being proposed as the best solution. It can be levied both directly by government agencies and also by the manufacturers themselves in the form of an additional collection. In this case, the market will determine the best method to package goods.

It is proposed introducing three indicators as a general established range on which the amount of the tax will depend in order to ensure practical implementation of the approach "let the polluter pay." The former takes into account the ratio of the weight of the packaging to its volume, the second—the number of times the packaging has been used, and the third—the cost of collecting and reprocessing used packaging. So, if the packaging manufacturer reduces its relative weight (the ratio of the weight of the packaging to the volume occupied by the packaged goods), the tax will be reduced correspondingly. The same will occur in the event of an increase of the number of times the packaging has been used.

As a result, an "additional" portion of the cost of packaging must be reduced to the amount of compensation for harming the environment which is a consequence of just the process of manufacturing and transporting packaging materials. Questions regarding other sources of environmental pollution, like the process of extracting bauxites that are needed to obtain material for aluminum cans, will be resolved separately by government organizations. Introduction of an additional collection to the cost of packaging to compensate for the impact of similar sources of pollution would result in the emergence of ineffective dual taxation.

The obvious difficulty when introducing a new tax system will consist of the fact that its amount will be different for various countries and various goods. So, the cost of avoiding the use of packaging in the United States will be much lower than in the Netherlands. In part this can be explained by the fact that there is a risk of obtaining a swimming pool during an attempt to dig a garbage pit. So, new taxes must be calculated on national and possibly even regional levels. Practical problems of organizing tax collection and their impact on the international trade process also arise.

Preliminary calculations of the amount of taxes for various types of packaging have led to interesting results. So, if we examine various types of containers used to package nonalcoholic beverages in Great Britain, the least amount of tax is for a cardboard container (obviously, primarily due to its low weight), the amount of tax will be higher for plastic bottles (made of polyethylene terephthalate), still higher for reusable (an average of 14 times) glass bottles, and also for aluminum cans. The tax for heavy glass disposable bottles is very high.

The listed calculations were conducted by independent researchers using specialists of the Swedish firm Tetra Pack, which is the largest producer of multilayer cardboard beverage cartons in the world.

*FINANCIAL TIMES*, 24 June 1992, p. 12.

## VARIOUS

### Wheelchair Permits Disabled Persons To Move While Standing

Rollei AB (Skelleftea, northern Sweden) has developed a new type of wheelchair with which a disabled person can be moved not only in the sitting position but also while standing at full height. Its developers—the firm's owners, the Degermans, father and son—are currently involved with manufacturing a prototype of this chair, which has received the designation RTS (Raise To Standing).

The RTS wheelchair can be gradually adjusted for height. Instead of ordinary belts to secure the position of the body, a disabled person can use front and side supports. Electric drives, control of which is carried out using switches located on the armrests and at the chair level, are used to change position and other operations. A person can stand in the chair not only straight up but also with a slight forward incline: that position is recommended as promoting strengthening of the skeletal system.

The inventors say that "this is not the first wheelchair that permits a disabled person to assume a vertical position, but it is the first one in which a disabled person can move in the vertical position." To do that, wheels equipped with hand rings which permit a disabled person to rotate the wheels have been made in such a way that they are accessible from any of the disabled person's body positions. These wheels are comparatively small in diameter in order to permit the wheelchair to be maneuvered in a restricted space. The fact that the chair's armrests are retractable downward and the disabled person can leave the chair from one of its sides is another advantage.

The RTS wheelchair is specifically recommended for patients who are paraplegics, polio sufferers, or people suffering from rheumatic diseases. A user of the wheelchair obtains greater independence, thanks to which a person's self-confidence increases. From the medical point of view, breathing is eased and digestion and blood circulation improve when the body is in a vertical position.

After some refinements, the RTS wheelchair will be ready for testing at the Swedish Institute for Problems of Disabled Persons and then for series production. The item has been patented; its development was financed by the Swedish National Committee for Industrial and Technical Development (NUTEK).

Rollei AB has already previously developed and produces several models of special wheelchairs. One of them, "Partner," facilitates accomplishment of various labor operations for the user. It is comfortable, height-adjustable using an electric drive, and has small dimensions. The other chair helps a disabled person to perform his natural hygiene needs.

*International Swedish Press Bureau, 29 June 1992.*

[No 42, 20 October 1992, pp 1-55]

[Text]

### "Moseroshow-92" Russian Aerospace Exhibition (Survey Continued)

## 6. Aircraft Armament

### Air-to-Air Missiles

The Vypel Moscow State Machine-Building Design Bureau (GosMKB), which is entering into an association with Speistekhnika, demonstrated aircraft guided missiles at the exhibition for the first time. A comparison of the data reported by the KB [Design Bureau] with the specifications of foreign missiles indicates that domestically produced missiles, as a rule, have somewhat larger dimensions and launch weight but a greater launch range, although the numbers clearly characterize the maximum unaimed range in the majority of cases. The emphasis on the development of medium-range missiles in Russia draws attention: the family of R-27 missiles has a large number of different variants that are equipped with various homing systems, in contrast to similar foreign missiles. A number of Russian missiles, especially the latest generation of series-produced R-73's and the newly developed RVV-AE generation, have substantial design innovations (for example, combined aerodynamic guidance and latticed control surfaces) that permit them to provide heightened maneuvering characteristics to missiles in contrast to similar foreign missiles. A brief description of Russian missiles with an indication of their specific features is cited below.

The R-27—is a medium-range aircraft guided missile. It is employed from aircraft launcher (APU) and catapult (AKU) devices against the following targets: highly maneuverable aircraft, helicopters, cruise missiles, etc. Destruction of targets is ensured on all aspect angles, during the day and at night, in simple and complex weather conditions, in the presence of natural or man-made interference, and in the background of ground and water surfaces with active countermeasures. It has been developed in the following variants:

R-27AE—a variant that has inertial guidance with radio correction and active radar homing in the terminal phase of flight. Independence of operations is ensured within seeker lock-on range. The multifunctional monopulse Doppler active radar seeker, developed by Agat MNII, provides search, lock-on, and tracking of moving targets based on preliminary target designation by the radars of the airborne launch platforms or anti-aircraft systems. The seeker has the following operating modes:

- totally autonomous (active) based upon initial target designation without the radar support of other radars in flight;
- inertial-correcting mode by a radar;
- and, a programmed mode under which the user can enter a new program for the onboard computer.

**Tactical-Technical Specifications of the Homing Head**

Launch range (with an R-27 type missile against a target with a $5 \text{ m}^2$ RCS [radar cross section])	Up to 70 km
Lock-on range of a target with a $5 \text{ m}^2$ RCS	No less than 20 km
Operating range of the correction channel (with a MiG-29 aircraft weapons control system)	Up to 50 km
Preparation time after preliminary switch-on for two minutes	No more than 1.5 seconds
Weight (without fairing)	No more than 14.5 kg
Diameter	200 mm
Length (without fairing)	600 mm

**R-27R**—a variant that has inertial guidance with radio correction and semiactive radar homing in the terminal phase of flight. Air Force spokesmen cited a launch range equal to 50 km at "Kubinka-92" and the developer's promotional materials indicated a range of 80 km at "Mosaeroshow-92" (obviously, this is the maximum range of an unaimed launch). The 9B-1101K inertial-semiactive radar seeker was also developed at Agat MNII. The seeker is designed to lock on to targets in altitude ranges from 20 to 25 km with a maximum altitude separation (vertical separation) of 10 km with target speeds of up to 3,500 kph [kilometers per hour] and a G-load of eight. The launch of two missiles against two targets is possible. It ensures the seeker's readiness for employment one second after receipt of the target designation from a MiG-29 type platform's weapons control system.

**Tactical-Technical Specifications of the 9B-1101K Homing Head**

Lock-on range of targets with a $3 \text{ m}^2$ RCS	25 km
Time for inertial guidance with radio correction with a maximum range from the launch platform of 25 km	30 seconds
Fuselage diameter	219 mm
Length (from the tip of the fairing)	1,173 mm
Weight	33.5 kg
Weight of the equipment section	21.5 kg
Ambient air operating temperature range	-55 - +60 °C
Maximum ambient air humidity at a temperature of +35 °C	98%
Maximum pressure	up to 14 mm of mercury

**R-27RE**—a modification of the R-27R variant with enhanced launch range. It is employed on MiG-29K, MiG-29M, MiG-29S, Su-27, Su-27K, and Yak-141 aircraft.

**R-27T**—a variant with all-aspect passive IR homing. It is employed based on the "fire and forget" principle. The

Air Force cited a 45 km launch range at the "Kubinka-92" Air Show and the developer's advertising at "Mosaeroshow-92" indicated a maximum launch range in the target's forward hemisphere of 72 km. A launch weight of 246 kg was cited at "Kubinka-92" and 254 kg at "Mosaeroshow-92."

**R-27TE**—a modification of the R-27T variant with enhanced launch range. It is utilized on MiG-29K, MiG-29M, MiG-29S, Su-27, Su-27K, and Yak-141 aircraft.

**R-27EM**—a variant that has inertial guidance with radio correction and semiactive radar homing in the terminal phase of flight. It is employed from aircraft launcher and catapult devices against the following targets: highly maneuverable aircraft, helicopters, Tomahawk cruise missiles, and Harpoon-type antiship missiles, etc., at a minimum altitude of three meters over water. It ensures destruction of targets in all aspect angles, during the day and at night, under simple or complex weather conditions, in the presence of natural or man-made interference, in the background of ground or water surfaces with active maneuvering, jamming, and weapons countermeasures.

**R-33E (AA-9 Amos)**—is a long-range aircraft guided missile that has inertial guidance and semiactive radar homing in the terminal phase of flight. It is employed on the MiG-31 aircraft from ventral aircraft catapult devices (four missiles are suspended) for interception of aircraft and cruise missiles. It ensures the destruction of targets that are flying at altitudes from 25-50 meters to 26-28 km over various surfaces at Mach 3.5 with an altitude separation or vertical separation of up to 10 km relative to the launch platform. Destruction of up to four targets simultaneously at various altitudes and intervals is possible. According to foreign data, the range is more than 160 km, although a total of 120 km was indicated at "Mosaeroshow-92."

**R-40T (AA-6 Acrid)**—a medium-range aircraft guided missile with a TGS [television seeker]. It also has a variant with a semiactive radar seeker. Range is approximately 72 km. It is utilized on MiG-31, MiG-25, and Su-15 aircraft.

**R-60 (AA-8 Aphid)**—close-range air-to-air missile with an infrared seeker. It is utilized on MiG-21, MiG-23M, MiG-25PD, MiG-29, MiG-29S, MiG-31, Su-24M, Su-25T, and Yak-38 aircraft.

**R-73 (AA-11 Archer)**—close-range aircraft guided missile. It is utilized on the MiG-21, MiG-23ML, MiG-29, MiG-29M, MiG-29S, MiG-29K, Su-27, Su-27K, Su-25T, and Yak-141. It has an all-aspect passive IR seeker and combined aerodynamic guidance. It is employed against the following targets: highly maneuverable aircraft, helicopters, cruise missiles, etc. It ensures destruction of targets at altitudes of up to 5 km in all aspect angles, during the day or at night, under simple or complex weather conditions, in the presence of natural or man-made interference, and in the background of ground or water surfaces. It exceeds existing similar

types of missiles based on maneuvering characteristics, does not impose restrictions on initial launch conditions, and is completely autonomous. It has target designation angles of 45° for the RMD1 variant and 60° for the RMD2 variant. It can serve to organize antimissile defense and permits realization of a reverse launch mode for defense of the launch platform's rear hemisphere. A missile length of 2,100 mm, a maximum launch range of 35 km, and a 7.4 kg warhead were indicated at the "Kubinka-92" Air Show and the developer cited these somewhat different figures for those missile parameters in the RMD1 variant at "Mosacrosow-92": 2,900 mm, 30 km, and 8 kg, respectively.

**RVV-AE**—A mockup of this medium-range aircraft guided missile with an active radar seeker system that is under development and which is similar to the American AIM-120 (AMRAAM) guided missile was displayed at the exhibition. Development of the missile has been ongoing for 10 years and it should replace existing R-73 missiles. The missile has low-aspect-ratio aerodynamic surfaces and four latticed control surfaces that are located in the tail section that increase the effectiveness of guidance and reduce the missile's RCS. It is employed against the following targets: highly maneuverable aircraft, cruise missiles, air-to-surface and air-to-air missiles, strategic bombers, helicopters, including in the hover mode, etc. It ensures destruction of targets from any direction in all aspect angles, during the day and at night, under simple or complex weather conditions, under conditions of electronic countermeasures, and in the background of ground or water surfaces based on the "fire and forget" principle, including with multichannel fire. In the future, it is envisioned configuring the missile with an IR homing warhead with in-flight lock-on. They also plan to develop a variant with a motor with increased dimensions to increase launch range at low altitudes and to destroy AWACS aircraft-type targets at ranges of up to 150 km or more. It is capable of attacking targets with a side angle of 90° (relative to the launch platform).

Tests have been successfully completed and it is proposed initiating series production of the missile for installation on the Su-27 and MiG-29 aircraft in the near future. Deliveries for export are proposed and organization of joint production is possible.

#### **Air-to-Surface Guided Missiles and Antiship Missiles**

Air-to-surface missiles that have been developed at various design collectives were displayed in pavilions and on the hardstand.

The Vympel GOSNKB [State Scientific Design Bureau] displayed various variants of the Kh-29 guided missile to destroy hardened ground and naval surface targets (steel-reinforced concrete shelters, concrete runways, large rail and vehicle bridges, ships, and surfaced submarines). The missile is manufactured based on a canard design and is equipped with a solid-fuel motor.

The **Kh-29L** guided missile has a semiactive laser seeker (illumination of the target from aircraft equipped with the Kayra, Klen, or Smerch optical-electronic systems or from ground-based laser target designators). Combat employment altitude is from 200 meters (maximum launch range of nearly 8 km) to 5,000 meters (maximum launch range of more than 10 km). Minimum launch range is 2-3 km. Seeker lock-on of the illuminated target is carried out prior to launch of the guided missile. It has a catapult missile launcher. Circular probable error when utilizing the Smerch guided missile system for missile guidance is 1-2 meters. The Smerch guided missile system is employed on the Su-25TK. The use of a helmet-mounted target designation system is possible.

The **Kh-29T** guided missile is equipped with a television seeker system and is designed to destroy surface ships with a displacement of up to 5,000-10,000 tonnes (destroyer or cruiser class), steel-reinforced concrete shelters, concrete runways, bridges, and industrial facilities. Seeker lock-on of the target is carried out prior to launch of the guided missile; a depiction of the acquired target is reproduced on a television display in the aircraft cockpit, after which the missile is fired from the launcher and executes an autonomous flight to the target. Maximum launch range (depending on the launch platform aircraft's altitude) is 10-12 km, minimum launch range is 2-3 km, and the launch altitude range is 200-5,000 meters.

The **Kh-29T** and **Kh-29L** guided missiles are equipped with 320 kg high-explosive-penetrating warheads and are employed from Su-25TK ground attack aircraft, from MiG-23BN, MiG-27K, MiG-27M, Su-17M3, Su-17M4, Su-24M and Su-27IB fighter-bombers, and from Su-27M and MiG-29M fighter aircraft.

During the Iran-Iraq War, Kh-29L guided missiles were delivered to Iraq and were successfully employed from MiG-23BN and F1E Mirage aircraft with the French ALTIS target designation system that is located in a pod (in this case, maximum launch range increased to 15 km).

The Zvezda Machine-Building Plant displayed a series of missiles designed to destroy various land and naval surface targets.

**Kh-25MP** antiradiation guided missiles (known in the West as the AS-12 Kegler), which are manufactured according to a canard design and equipped with a solid fuel motor, are designed to destroy enemy radars at a range of up to 40-60 km. Hawk surface-to-air missiles and the improved variant are the missile's typical targets. Maximum guided missile speed is 900 meters per second [mps].

The **Kh-25L** missile has a semiactive laser seeker, launch range (depending on the flight altitude of the launch

platform aircraft) is 10-20 km and maximum speed is 850 mps. A variant of the guided missile with a thermal seeker has been developed for use at night (maximum launch range is 10-20 km).

The Kh-25MR guided missile is equipped with a radio command guidance system, attains a maximum speed of 860 mps, and maximum launch range reaches 10 km.

MiG-21, MiG-23, MiG-27, MiG-29, Su-17M, Su-24, Su-25, Yak-38, and Yak-41M aircraft and also helicopters are equipped with the Kh-25M family of missiles. This type of guided missile is similar in dimensions, weight, and primary specifications to the American-made Hughes AGM-65 Maverick family of guided missiles and somewhat exceed the latter in maximum speed. However, a thermal seeker that permits effective use of the missile at night was introduced earlier on the American guided missiles.

The Kh-31A antiship guided missile is equipped with a combined solid-fuel/ramjet engine and active radar seeker. The missile is manufactured based on a normal aerodynamic design with a low-aspect-ratio wing. Four circular air intakes covered by cone-shaped protective caps that are jettisoned in flight are located along the sides of the fuselage.

Based on its primary specifications and design solutions, the Kh-31A guided missile is close to the Franco-German ANS missile which is in the stage of development (however, the domestically produced missile has a somewhat greater maximum speed). The guided missile is capable of destroying targets when jamming is being used.

MiG-29M, MiG-29K (an aircraft with a guided missile was displayed on the hardstand), MiG-27K (an aircraft with a guided missile was displayed on the hardstand), Su-27M, Su-27IB, Yak-41M, and also helicopters are armed (or are proposed to be armed) with this missile.

According to the developing firm, at the present time the Kh-31P antiradiation guided missile is the best missile of its class in the world. The guided missile is capable of effectively destroying all existing types of air defense medium- and long-range surface-to-air missile radars (including the best American Patriot surface-to-air missile system) and also early warning and air traffic control radars. The firm states that the Kh-31P exceeds the American AGM-88 HARM guided missile and the French ARMAT in its combat specifications. MiG-21 and MiG-23BN (after completion of modernization work), MiG-27M, MiG-29M, MiG-29K, Su-24M, Su-27M, Su-27IB, and Yak-41M aircraft are platforms for this missile. Structurally, the Kh-31P is similar to the Kh-31A and differences consist of the guidance system and less powerful warhead. The maximum speed of the Kh-31 missile family is 1,000 mps. The developing firm states that the combat capabilities of aircraft should increase by a factor of 3-5 after they have been armed with its family of missiles.

The Kh-35 guided missile (Western designation—SS-N-25) is a missile with transonic speed (300 mps) and is equipped with a turbojet bypass sustainer engine. Its development began in 1983 based on a Navy order which was interested in an antiship missile to arm light ships (craft) and aircraft. The entry of the aircraft variant of the missile into the inventory of the CIS countries' air forces and navies is anticipated in 1994.

The guided missile is manufactured based on a normal aerodynamic design and has a folding wing and tail assembly. A trapezoidal air intake is located in the lower portion of the fuselage. A variant of the missile that is designed for launch from ships, ground-based launchers, and helicopters is equipped with a solid fuel rocket booster engine and has a high-aspect-ratio folding cruciform tail assembly. It has an active radar guidance system on the terminal phase of the trajectory that is capable of operating under conditions of electronic countermeasures. The missile's combat effectiveness increases due to flight at extremely low altitudes (3-5 meters depending on the height of the waves) which significantly complicates interception of the guided missile by shipborne antimissile systems. The missile is equipped with a 145 kg high-explosive-fragmentation-incendiary warhead armed with high explosives.

After appropriate refitting, practically all types of tactical aircraft (including the MiG-21, which is capable of carrying one Kh-35 guided missile on a ventral hard point), the Tu-142 antisubmarine warfare aircraft (eight missiles located on two underwing hard points), and also the Ka-27 and Ka-28 helicopters can be launch platforms for the aircraft variant of the missile (without the booster rocket). The shipborne variant of the guided missile, which is part of the Uran system, is accommodated in transport-launch canisters, grouped in packages of four each, on missile boats and small missile ships and also on ships of other classes (SKR's [escort vessels] and BPK's [large antisubmarine warfare ships]) during the course of their modernization.

A drawing of a coastal defense system using Kh-35 guided missiles was displayed at the exhibition. The self-propelled system, mounted on a four-axle off-road chassis, includes a command and control and communications vehicle equipped with a radar on a mobile mast, a launcher with eight transport-launch canisters, and also a transloader [transporter-loader] vehicle that carries eight transport-launch canisters and a crane. Launch of the coastal variant of the Kh-35 can also be accomplished from closed positions.

Based on its design solutions and tactical-technical specifications, the Kh-35 missile is close to the American AGM/RGM-84 Harpoon antiship guided missile, however, according to the developing firm's statement, it somewhat exceeds the latter in combat effectiveness (the Kh-35 has a somewhat greater launch range and weighs 80 kg less).

Information on a future antiship missile in the stage of development at the present time was presented at the Almaz NPO [Scientific Production Association] Pavilion. The all-weather supersonic missile is designed to destroy hardened single or group naval surface targets and is equipped with a solid-fuel rocket motor. A launch is conducted from a transport-launch canister at angles of 19-90° (depending on the type of launch platforms). Maximum launch range is 250 km. It is proposed using future nuclear submarines and also reequipped nuclear submarines of old designs as missile launch platforms (the capability to install a package of several missiles in SLBM [submarine-launched ballistic missile] launch tubes is envisioned). Furthermore, it is planned to arm surface combatants of various classes (destroyers, cruisers) and also ground-based self-propelled coastal defense mounts (the installation of three missiles launched at a slant on one four-axle off-road motor vehicle is envisioned) with the new guided missile.

A Moskvit supersonic heavy antiship missile designed to destroy major surface targets was suspended on a ventral hardpoint on a special pylon under a Su-27K aircraft displayed on the exhibition's hardstand. The missile's length is 9.7 m, launch weight is 4,500 kg, launch range is 150-250 km (depending on the flight altitude of the missile launch platform aircraft), and it has a 320 kg warhead. The guided missile is equipped with a combined solid-fuel ramjet engine, has four semicircular air intakes with a central cone, a folding wing, and low-aspect-ratio tail assembly. Utilization of both passive and active homing systems is possible.

Sovremennyy class destroyers (eight launchers), missile boats (four launchers), Sivuch class hydrofoils (eight launchers), and also wing-in-ground effect vehicles are equipped with the shipborne variant of this missile (known in the West as the SS-N-22).

Information on the state of work on the future aircraft guided missile was reported to journalists during the course of the exhibition's operation.

FLIGHT INTERNATIONAL magazine reported on the cessation of work, for financial considerations, on the program to develop an improved, strategic, supersonic, stealth cruise missile, which is known in the West as the AS-19. The development of this missile, which is designed to equip the Tu-160 and Tu-95MS bombers, was begun in the mid-1980's and its entry into the inventory was planned for the mid-1990's. The missile was designed to replace the RKV-15B cruise missile (AS-15). The cruise missile has a maximum launch range of approximately 4,000 km and carries two warheads with independent guidance that are capable of detecting and attacking targets up to 100 km from each other. The conduct of the cruise missile program's flight tests has been impeded for political reasons (the test ranges where the launches are being conducted are located on the territory of the Republic of Kazakhstan).

A hypersonic aeroballistic antiship missile (a modification of the RKV-500B short-range nuclear aircraft missile known in the West as the AS-16 Kickback) has a launch weight of 1,200 kg and is externally similar to the American AGM-69 SRAM aircraft missile with which American B-52, B-1B, and B-2 bombers are armed. The antiship missile can be mounted on Tu-160 and Tu-22M bomber drum launchers. The missile is equipped with an inertial guidance system that is used on the cruise portion of the trajectory and an active radar seeker that operates in the millimeter band. The launch range of the antiship missile is 60-150 km. After launch, the missile carries out a supersonic cruising flight using aerodynamic lift and, in the terminal phase, moves along a ballistic trajectory with a speed equivalent to Mach 5.

A subsonic medium-range antiship missile known in the West as the AS-18 can be accommodated both on ships and on aircraft. The antiship missile is 5 meters long, is manufactured based on a canard design with a cruciform wing and tail assembly, is equipped with a solid-fuel rocket engine installed in a pod under the fuselage, and has a 315-kg warhead and a maximum launch range of 200 km. The guidance system is inertial for the cruise phase of the trajectory with a radar seeker for the terminal phase.

Specifications of Russian and Foreign Air-to-Air Missiles

Model	Class	Guidance	Length, mm	Caliber, mm	Wingspan, mm	Control surface span, mm	Launch weight, kg
<b>Short-Range Missiles</b>							
R-60	Air-to-Air	IR Seeker	2,100	120	—	—	45
R-73 RMD1	Air-to-Air	IR Seeker	2,900	170	510	Data not available	105
R-73 RMD2	Air-to-Air	IR Seeker	2,900	170	510	Data not available	110
AIM-9L	Air-to-Air	IR Seeker	2,870	127	630	Data not available	86.6
R550 Magic	Air-to-Air	IR Seeker	2,750	157	660	Data not available	90
ASRAAM	Air-to-Air	IR Seeker	2,900	166	Data not available	Data not available	87

## Specifications of Russian and Foreign Air-to-Air Missiles (Continued)

Model	Class	Guidance	Length, mm	Caliber, mm	Wingspan, mm	Control surface span, mm	Launch weight, kg
<b>Medium-Range Missiles</b>							
R-27AE	Air-to-Air	Inertial guidance with radio update + active radar homing	4,780	260	800	970	350
R-27R	Air-to-Air	Inertial guidance with radio update + semiactive radar homing	4,080	230	770	970	253
R-27RE	Air-to-Air	Inertial guidance with radio update + semiactive radar homing	4,780	260	800	970	350
R-27T	Air-to-Air	IR Seeker	3,795	230	770	970	254
R-27TE	Air-to-Air	IR Seeker	4,500	260	800	970	343
R-27EM	Air-to-Air	Inertial guidance with radio update + semiactive radar homing	4,780	260	800	970	350
RVV-AE	Air-to-Air	Semiactive radar homing	3,600	200	Data not available	Data not available	175
AIM-7M	Air-to-Air	Semiactive radar homing	3,700	200	1,000	Data not available	228
Sky Flash	Air-to-Air	Semiactive radar homing	3,700	203	1,020	Data not available	192.3
AIM-120	Air-to-Air	Inertial guidance with active radar homing	3,650	178	526	Data not available	156.5
MICA	Air-to-Air	Inertial guidance + semiactive radar homing or Infrared homing	3,100	Data not available	Data not available	Data not available	110
<b>Long-Range Missiles</b>							
R-33E	Air-to-Air	Inertial guidance + semiactive radar homing	4,150	380	900	1,180	490
AIM-54	Air-to-Air	Inertial guidance + semiactive radar homing	4,000	380	915	Data not available	443

Model	Warhead Weight, kg	Warhead Type	Launch Range, km		Maximum Altitude of Destroyed Targets, km	G-Load of Destroyed Targets
			Maximum	Minimum		
Short-Range Missiles						
R-60	3.5	—	10	—	—	—
R-73 RMD1	8	Continuous rod	30	0.3	20	12
R-73 RMD2	8	Continuous rod	40	0.3	20	12
AIM-9L	9.5	High-explosive fragmentation	18	Data not available	Data not available	Data not available
R550 Magic	12.5	High-explosive	10	0.3	Data not available	Data not available
ASRAAM	—	Data not available	15	0.3	Data not available	Data not available
Medium-Range Missiles						
R-27AE	39	Continuous rod	130	0.5	27	8
R-27R	39	Continuous rod	80	0.5	25	8
R-27RE	39	Continuous rod	130	0.5	27	8
R-27T	39	Continuous rod	72	0.5	24	8
R-27TE	39	Continuous rod	120	0.5	30	8
R-27EM	39	Continuous rod	170	0.5	27	8
RVV-AE	Data not available	Data not available	90	Data not available	Data not available	12
AIM-7M	40	Continuous rod	100	0.6	Data not available	Data not available
Sky Flash	30	Continuous rod	50	Data not available	Data not available	Data not available
AIM-120	20	Fragmentation	75	Data not available	Data not available	Data not available
MICA	10	High-explosive	60	Data not available	Data not available	Data not available
Long-Range Missiles						
R-33E	47	High-explosive fragmentation	120	Data not available	28	Data not available
AIM-54	60	Continuous rod	200	Data not available	Data not available	Data not available

### Specifications of Air-to-Surface Guided Missiles

	Type of Guided Missile									
	Kh-25MR	Kh-25MP	Kh-25ML	Kh-29T	Kh-29L	Kh-31P	Kh-31A	Kh-35	Kh-58U	Shturm
Missile length, mm	4,353	3,830	4,255	3,875	3,875	4,700	4,700	4,400	4,800	1,840
Missile diameter, mm	275	275	275	380	380	360	360	420	380	130
Wing span, m	—	—	—	1.100	1.100	—	—	—	—	—
Launch weight, kg	300	320	300	680	660	600	600	600	640	32
Warhead weight, kg	90	90	90	320	320	90	90	145	160	6
Maximum aimed launch range, km	8-10	40	10-20	10-12	8-10	100	50	130	50	5
Minimum aimed launch range, km	—	—	—	2-3	2-3	—	—	—	—	—
Maximum launch altitude, m	—	—	—	5,000	5,000	—	—	—	—	—
Minimum launch altitude, m	—	—	—	200	200	—	—	—	—	—
Type of guidance system	Radio command guidance	Antiradiation missile	Laser guidance	Television guidance	Laser guidance	Antiradiation missile	Active radar guidance system	Active radar guidance system	Antiradiation missile	Radio command guidance

### Antisubmarine Warfare Weapons

Several guided aircraft weapons systems that have no equals in the navies of foreign countries were displayed at the exhibition.

A mock-up of the APR-2Ye aircraft antisubmarine solid-fuel missile torpedo developed by the Region GNPP [State Scientific Production Association] and designed to destroy submarines moving at speeds of up to 80 kph (43 knots) at a depth of up to 600 meters (the future American Seawolf nuclear submarine under construction at the present time should have a maximum speed of 35 knots and a maximum depth of up to 500 meters) was demonstrated on a stand. The missile's guidance system is hydroacoustic with phase correlation. Target lock-on range is 1,500 meters, space surveillance sector by the guidance system is 90 x 45°. The probability of destruction of a submarine at a depth of 300-500 meters is 70-85%. The guided missile is dropped from a helicopter, after which the missile begins a target search in the autonomous mode, and time of completion of the combat mission is 1-2 minutes.

The system includes the AKIP-1Ye automatic verification unit, a PA-2 training missile-torpedo, and an A4

simulator that ensures rehearsal of the combat mission without dropping the missile-torpedo.

The SZV guided depth bomb is designed to destroy modern and future submarines from periscope depth to 600 meters. The small munition does not have a power plant and it is planned to use hydrodynamic force at an angle of 60°. The depth bomb's trajectory can be changed within 120°. It has an active hydroacoustic guidance system. The probability of destruction of a submarine increased by a factor of 1.2-1.5 in contrast to depth bombs at depths of up to 200 meters, and by a factor of up to 4-8 at depths of 200-600 meters. A 19 kg shaped warhead has been employed on the depth bomb.

A full-scale mockup of the Zapad rocket-propelled guided bomb designed for use with a standard shipborne RBU-6000 which was developed for firing unguided rocket-propelled depth bombs and installed on many domestically produced and foreign combat ships was demonstrated.

The bomb has a hydroacoustic guidance system (submarine detection range—130 meters) and can be employed at distances of 600-4,300 meters, the sailing depth of the submarine being fired at can reach 1,000 meters and the probability of its destruction is 0.8.

Specifications of Antisubmarine Weaponry

System Class	Type of System		
	Zapad	APR-2Ye	SZV
	Rocket-assisted depth bomb	Missile-torpedo	Guided depth bomb
Length, m [as published]	1,832	3,700	1,300
Diameter, m [as published]	213	350	211
Weight, kg	112.5	575	94
Warhead weight, kg	—	100	19
Range of combat employment, m	600-4,300	1,500	—
Projectile speed, kph	—	115	16.2 mps*
Target sailing depth, m	1,000	600	600
Target speed, kph	—	80	—
Type of platforms	Surface ships	Aircraft	Aircraft

\* Maximum speed of submergence

The munitions presented at the exhibition are distinguished by their relative simplicity of design and low cost, they can be used from various classes of ships and aircraft, and at the same time they approximate significantly more complex Western systems in combat effectiveness.

### Guided Aircraft Bombs

At the present time, guided bombs are one of the most effective types of aircraft weaponry, combining high destruction accuracy with the relatively low cost of the munition.

Materials on KAB-500Kr and KAB-1500 bombs that have television and laser guidance, respectively, were

presented at the exhibition. The KAB-500Kr bomb is designed to destroy fixed ground-based targets (rail bridges and fortified transportation hubs during the day under good weather conditions). The correlational type television guidance system provides the capability to destroy camouflaged targets. In contrast to other types of guided aircraft bombs, specifically, the American Walleye bombs that lock on to an optically contrasting target, the KAB-500Kr's seeker head records the relative position of various optically contrasting objects and in the process the target itself does not have to be separated from the background of the terrain and the munition will be guided to an arbitrary point assigned by a marker.

After release from the aircraft, the bomb is completely autonomous and requires correction and the circular probable error is 4-7 meters. The munition is equipped with a

380 kg armor-piercing warhead that is designed to destroy well-fortified targets (there is also a variant with a high-explosive warhead that ensures a destruction area of 1,500 m<sup>2</sup>). The range of speeds of the aircraft-platforms during release of the munition is 550-1,100 kph and the range of release altitudes is 500-5,000 meters.

The KAB-500Kr-U training munition, which permits simulation of the entire bombing cycle and records its results without an actual bomb drop (the KAB-500Kr-U is a nondroppable canister weighing 85 kg, is 1,830 mm long and 350 mm in diameter, and is equipped with a television system similar to the one installed on the KAB-500Kr bomb that is attached to the aircraft's external hardpoints), has been developed to rehearse combat employment of the KAB-500Kr.

The KAB-1500L-Pr powerful guided bomb is designed to equip frontal and long-range aviation aircraft. Its targets are small, super-hardened facilities or facilities that are buried deep in the earth (powerful fortifications, nuclear munitions dumps, strategic command posts).

The munition consists of a semiactive laser seeker that ensures a circular probable error of 7-10 meters (up to

1-2 meters on the latest modifications) and is manufactured according to a canard design. A cruciform wing with deployable outboard wings is located in the tail section, behind which are biplane control surfaces that ensure high maneuvering characteristics. A special sub-caliber armor-piercing incendiary warhead is utilized in the bomb that is capable of penetrating 10-20 meters into the ground and piercing the covers of fortifications up to 2 meters thick.

The KAB-1500L-F munition is equipped with a warhead that is utilized in the FAB-1500 standard free-fall bomb (upon detonation, a 20 meter diameter crater is formed) and is similar to the KAB-1500L-Pr bomb in the remainder. The KAB-1500L-Pr bomb's range of combat employment altitudes realized during utilization of the munition from frontal aviation aircraft is 500-5,000 meters (KAB-1500L-F—1,000-5,000 meters) at bombing speeds of 550-1,100 kph (expansion of these parameters is possible in the future).

In April 1992, a KAB-500L bomb with a laser guidance system and high-explosive warhead was displayed at the "Kubinka-92" Air Show.

#### Specifications of Guided Bombs

	Type of Munition			
	KAB-500Kr	KAB-500L	KAB-1500L-F	KAB-1500L-Pr
Type of guidance system	Television	Laser	Laser	Laser
Length, mm	3,050	3,050	4,600	4,600
Diameter, mm	350	400	580	580
Wingspan, mm	850	—	850/1,300*	850/1,300*
Bomb weight, kg	560	534	1,560	1,500
Warhead weight, kg	380	—	1,180	1,100
Type of warhead	Armor-piercing	High-explosive	High-explosive	Armor-piercing
Bombing altitude, km	0.5-5.0	—	1.0-5.0	0.5-5.0
Circular probable error, m	4.7	—	7-10	7-10

\*In a calculation with a folded/extended wing

The Impuls State Scientific Production Association presented information on a television seeker for various types of guided aircraft bombs. The television seeker is designed for use in 250 to 4,000 kg precision guided munitions with target lock-on prior to launch. The munitions can be utilized from both domestically produced and foreign aircraft (specifically, from Mirage and SEPECAT Jaguar fighter aircraft). Target selection and lock-on is carried out using a television display in the weapons-carrying aircraft cockpit.

The television seeker ensures precision guidance of the bomb against small targets such as cruise missile and mobile surface-to-air missile [SAM] launchers, command and control centers, ships, bridges, etc. The television seeker has been successfully tested in a combat situation. Based on a customer's requirement, it can be

modernized for a specific type of aircraft and manufactured based on a buyer's product base.

#### Specifications of the Television Seeker

Spectral range	0.4-0.95 microns
Illumination	50-10,000 lux
Field of view	2-3°
Television standard	625 lines, 50 Hz
Resolution	550 lines
Guidance accuracy	2-3 meters
Contrast of targets	Any, including camouflaged targets

Domestically produced guided aircraft bombs with television and laser systems do not lag behind similar

American munitions based upon primary specifications, however, a certain lag has been observed in guided aircraft bombs that are equipped with infrared imaging guidance systems (no munitions with an IR guidance system were displayed at the exhibition).

### Unguided Aircraft Rockets

Various types of unguided aircraft rockets and pods for them that are designed for installation on various types of combat aircraft and helicopters were demonstrated at pavilions and on hardstands.

The S-8 (80 mm) aircraft rocket system, with which the Su-17M, Su-24, Su-25, Su-27, MiG-23, and MiG-27 aircraft and also the Mi-8, Mi-24, Mi-28, and Ka-25 helicopters are equipped, was displayed along with the widely known S-5 57 mm unguided aircraft rockets. B-8M1 launch pods that are designed for 20 rockets (length—3,550 mm, diameter—410 mm, empty weight—160 kg, loaded weight—400 kg) and have improved aerodynamics with a conical nose section are used to launch them from aircraft. B-8V20 pods that also have a 20 rocket capacity (length 1,790 mm, diameter—521 mm, empty weight—100 kg, and loaded weight—342 kg) are used on helicopters.

The rocket is equipped with a solid-fuel motor and has various warhead configurations.

Primary Tactical-Technical Specifications of Different Variants of S-8 Unguided Aircraft Rockets

	Type of Rocket			
	S-8KOM	S-8BM	S-8DM	S-8OM
Type of warhead	Shaped-fragmentation	Concrete-piercing with a penetrating warhead	With a fuel-air explosive	Illuminating
Rocket length, mm	1,570	1,540	1,700	1,632
Rocket weight, kg	11.3	15.2	11.6	12.1
Warhead weight, kg	3.6	7.41	3.63	4.3
Weight of explosives (mixture, composition), kg	0.9	0.6	2.15	1.0
Launch range, km	1.3-4.0	1.2-2.2	1.3-3.0	4.0-4.5
Effectiveness	Capability to penetrate 400 mm armor	Capability to penetrate 800 mm of steel-reinforced concrete	5.5-6.0 kg TNT equivalent	2 Mkd of light
Range of combat employment speeds, mps	166-330	166-330	166-330	166-330

The S-13 122 mm unguided aircraft rocket launched from the B-13 launch pod with a five rocket capacity is another powerful rocket that was displayed at the exhibition. Su-27 and MiG-29 fighter aircraft, Su-25 ground attack aircraft, and also the future Su-37 strike aircraft are equipped with this type of pod (weight of empty

pod—160 kg, weight of loaded pod—510 kg, length—3,558 mm, and diameter—410 mm).

S-24 and S-25 large caliber unguided aircraft rockets are launched from identical launchers and there are no similar foreign rockets at the present time. A variant of the S-25 rocket with a semiactive laser guidance system was demonstrated at the exhibition.

Specifications of Large Caliber Unguided Aircraft Rockets

	Type of Rocket				
	S-13OF	S-13T	S-24B	S-25OF	S-25OFM
Type of warhead	High-explosive-fragmentation	Penetrating	High-explosive-fragmentation	High-explosive-fragmentation	High-explosive-fragmentation
Caliber, mm	122	122	240	340	340
Length, mm	1,800	1,800	2,330	3,307	3,310
Rocket weight, kg	68	67	235	381	480
Warhead weight, kg	32.2	31.8	123	150	190
Launch range, km	2.5	2.5	2.0	3.0	3.0
Effectiveness	1,800 fragments	Penetrates 1 meter of concrete	4,000 fragments	6,500 fragments	Destroys 1,820 m <sup>2</sup>

### Aircraft Artillery Weapons

Gun mounts that are designed for suspension on various types of combat aircraft and helicopters were demonstrated at the exhibition's pavilions. The mobile gun-cannon mounts manufactured by MMPP have a remote control system in one or two planes with an electric drive and selsyn communications with a target assigning device. They are designed to destroy point and lengthy, lightly defended targets and also airborne targets using 7.62 to 23 mm guns with a basic load that is sufficient to accomplish several attacks. The mounts function without recoil at temperatures from -60 to +60 °C and at altitudes up to 15,000 m, are simple to operate, reliable, and require minimum time to prepare for use. The pod mounts can be hung on aircraft and helicopters that have third group beam brackets (up to a 500 kg capacity).

The SPPU-6 removable gun mount is armed with a 9A-620 or 9A-768 23 mm six-barrel gun with a rate of fire of 9,000-10,000 rounds per minute. The gun can be aimed in the vertical plane to 8°. Guidance along the azimuth (to an angle of up to 12°) is provided by rotating the entire canister around the longitudinal axis. The SPPU-6 pod is designed for installation on two-seat combat aircraft (specifically, the Su-27UB) and the second crew member carries out aiming. The SPPU-6 weighs 525 kg, is 5 meters long, 0.5 meters in diameter, and the basic load is 400 rounds.

The UAK-23-250 pod with the GSh-23 (23 mm) gun can be attached to the external hard points of various types of aircraft or helicopters. The pod is 3,166 mm long, 340 mm in diameter, weighs 217 kg, and has a basic load of 250 rounds.

The SPPU-1 pod, also armed with a GSh-23 gun with a 3,400 rounds per minute rate of fire, has a system to divert the gun's barrels 30° below which provides the capability to conduct fire against ground-based targets in horizontal flight. The pod's basic load is 260 rounds and it weighs 290 kg.

The GUV universal helicopter pod can be equipped with one YaKB-12.7 (12.7 mm) machine gun or two GShG's. The basic load is 4,350 rounds, dimensions 3,000 x 480 mm, empty weight—140 kg, loaded weight—452 kg.

The NUV-1UM machine gun turret mount with remote control is armed with a 9A-622 four-barrel machine gun (7.62 mm, 6,000 round per minute rate of fire). Angles of vertical laying are 0-30°, horizontal -30-+28°. Weight of the mount is 27 kg and, in particular, the Ka-29 helicopter is armed with it.

A removable, mobile gun mount for firing at ground-based and airborne targets equipped with a GSh-30-1 gun (30 mm, 1,500 rounds per minute) aimed in the horizontal plane to -15-+15° and to 0-30° in the vertical was demonstrated on the Dzerzhinets MAZ hardstand. It has an electric remote control servo aiming drive. The system's basic load is 150 rounds, weight—480 kg, dimensions—3,030 x 540 x 550 mm. The mount can be

hung on a beam bracket or can be attached directly to the aircraft airframe. The SPPU is designed to equip Su-25 ground attack aircraft and is undergoing testing at the present time.

### 7. Ground-Based and Shipborne Missile and Artillery Systems

#### Antiaircraft Missile Weapons

The division that reflects work in the sphere of developing antiaircraft weapons was one of the most represented at the exhibition. Many promising SAM systems that are being prepared for acceptance into the inventories of the CIS countries troops were demonstrated here.

The Antey Concern displayed the S-300V Mobile SAM System (known in the West under the designation SA-12A/SA-12B), which is designed for defense of troop formations and the front's most important facilities from tactical or operational-tactical ballistic missiles, and also from aircraft, cruise missiles, and UAV's (unmanned aerial vehicles). The system has high jam-proofing and is capable of simultaneously firing at up to 24 targets with guidance of up to two missiles from one launcher or up to four missiles from two launchers against each target. The entire combat operations process has been automated to the maximum extent possible thanks to the use of high-speed digital computers.

The SAM system (up to four units) and the detection and target designation unit are part of the system's combat components that are entirely mounted on off-road tracked chassis and are equipped with protective devices from the destructive factors of nuclear weapons. The latter includes a command post, a 360° surveillance radar, and a sector surveillance radar (all the radars have phased array antennas). Each SAM unit consists of multichannel missile guidance equipment and six launchers of two types: type 1 for two long-range missiles that are designed to intercept Pershing class intermediate-range ballistic missiles and type 2 for four lesser-range missiles that are designed to intercept Lance/Scud class short-range ballistic missiles.

Type 1 missiles are equipped with an additional solid-fuel booster which provides them with a flight speed of up to 2,400 mps and a maximum guaranteed target destruction range of up to 100 km (during tests, an aerodynamic target was intercepted at a range of 204 km). The single-stage type 2 missile attains a maximum speed of 1,700 mps. The remaining portions of the type 1 and type 2 missiles have been standardized to the maximum possible degree. The fuselage is nearly a conical shape (similar to Spirit and Arrow antimissile fuselages) and is equipped with a radar translucent nose fairing that is capable of withstanding dynamic head and kinetic heating at speeds that correspond to Mach 6.5. It has a combined guidance system: inertial—in the cruise phase of the trajectory and semiactive radar—in the terminal phase. Target illumination is carried out using a special radar with round antennas that are mounted on each launcher and are raised up on special masts that permits it to conduct fire from positions in a city, forest, or rugged terrain.

Using the S-300V system, you can intercept targets with an RCS of approximately  $0.02 \text{ m}^2$ , which permits you to combat small cruise missiles and aircraft manufactured using Stealth technology (according to the assessments of American experts, the minimum RCS in a course projection of the B-2 stealth bomber is  $0.02\text{-}0.05 \text{ m}^2$  and the RCS of the F-117A and F-22 aircraft is somewhat greater). Lock-on and automatic tracking of MIRV'd targets (specifically, of ballistic missile warheads) is possible.

The missile is equipped with a directed energy warhead (before detonation of the warhead, the missile is oriented in a bank in the appropriate manner). The fuze has two positions: for operations against aerodynamic targets (destruction of aircraft in the central section); for operations against ballistic missiles (destruction of the warhead).

#### Specifications of the S-300V SAM System

##### Guaranteed target destruction range, km:

Aerodynamic	100
Ballistic	40

##### Minimum target destruction altitude, m:

Aerodynamic	25
Ballistic	2,000

##### Maximum target destruction altitude, m:

Aerodynamic	30,000
Ballistic	25,000

Range of speeds of destroyed targets, mps	0-3,000
Number of targets being fired on simultaneously	Up to 24
Number of missiles being guided simultaneously	Up to 48
Rate of fire, seconds	1.5
Missile preparation time for launch, seconds	15
System deployment or teardown time, minutes	5
System basic load (depending on launcher configuration)	96-192

The S-300V system has been accepted into the Russian ground forces inventory and is being series produced (the combat vehicles that were displayed at the exhibition are part of a system that arrived from a line unit where they performed combat alert duty).

Based on its combat capabilities the S-300V system has no equals in the world at the present time. Systems with specifications that approximate the specifications of the domestically produced system are being developed abroad within the framework of the American SDI Program and are only in the developmental stage.

Israel, jointly with the United States, is developing the Arrow Regional Antiballistic Missile [ABM] Defense System that is closest in capabilities to the S-300V SAM System, which they plan to accept into their inventory at the end of the 1990's. In the United States, work is being conducted on the LEDI (Low Endoatmospheric Defense

Interceptor) Tactical ABM System. Furthermore, modernization of the Patriot MIM-104 SAM System is being conducted within the framework of the PAC (Patriot Antitactical Missile Capability) program directed at increasing its capabilities to combat ballistic missiles (missiles modernized during the course of the first stage of this program participated in combat operations in the Persian Gulf region in the winter of 1991). Comparative specifications of the antimissile capabilities of the S-300V SAM and future foreign antimissile systems are cited in the table.

#### Comparative Specifications of Tactical Antimissile Systems

	Type of system			
	S-300V	MIM-104 PAC-2	MIM-104 PAC-3	Arrow
Year of acceptance into inventory	1980's	1990	1999 <sup>*</sup>	1997 <sup>*</sup>
Maximum speed of intercepted ballistic missiles, mps	3,000	1,800	—	3,000
Maximum ballistic missile interception range, m	40,000	20,000	40,000	90,000
Maximum ballistic missile interception altitude, m	25,000	7,500	20,000	40,000
Minimum ballistic missile interception altitude, m	2,000	—	—	10,000

<sup>\*</sup> Tentative time of acceptance into inventory

The Tor All-Weather SAM System (known in the West as the SA-15) was developed by Antey Concern and is designed to accomplish air defense missions at the battalion level. The system will permit them to provide effective defense of facilities from surprise strikes of guided missiles, guided bombs, aircraft, helicopters, and UAV's.

The system with a transported basic load (eight missiles in vertical armored launchers) is mounted on a single armored tracked chassis that has adjustable clearance and can be transported by all types of transportation, including aircraft (chassis weight is 34,250 kg, maximum speed along hard-surfaced roads is 65 kph). The crew consists of the commander, operator, and driver-mechanic.

The system is equipped with a C-band Doppler surveillance radar capable of detecting targets while moving (detection range—up to 25 km, number of simultaneously detected targets—48, number of track-while-scan targets—10). The assessment of the degree of threat and selection of priority targets are conducted automatically. The radar antenna folds in the travel position. The Doppler fire control radar with a phased

array antenna that operates in the K-band is capable of simultaneously identifying and tracking up to two targets within a 15 x 15° operating sector. The system also has an optical detection and sighting device (detection range of a typical target—20 km). Two targets can be fired at simultaneously.

The 9M330 single-stage solid-fuel missile with a radio command guidance system that is part of the Tor system is manufactured according to a canard design and is equipped with a folding wing and tail assembly. It is transported and stored in transport-launch canisters (four missiles in each).

The launch of the guided missile is carried out vertically from a canister using a catapult. Turning the missile onto the combat course after it leaves the launcher is carried out using gas control surfaces in the missile's nose section. The missile's maximum speed is 850 mps and the maximum maneuverable G-load is 30.

A special transloader vehicle (TZM) is utilized to transport an additional basic load of missiles and the loading device. A simulator has been provided to train system operators.

#### Specifications of the 9M330 SAM System

Weight of the system	34,250 kg
Weight of the guided missile	165 kg
Warhead weight	15 kg
Maximum guaranteed destruction range	12,000 m
Minimum target destruction altitude	10 m
Maximum target destruction altitude	6,000 m
Maximum speed of the missile	850 mps
Range of speeds of destroyed targets	10-700 mps
Reaction time from the moment of target detection	5-8 seconds

During the exhibition it was reported that approximately 200 Tor SAM Systems have been delivered to the troops of the CIS countries. The Tor systems are replacing the Osa 9K33 Battalion Element Mobile SAM System which is widely used in CIS countries armed forces and which has not been confirmed by the American side, an F-117A stealth aircraft was shot down by an Iraqi Osa SAM System during the course of military operations in the Persian Gulf region. One of the latest modifications of this system—the Osa-AK 9K33M3 SAM System—has the following specifications: detection range of a typical target—28 km, target altitude range—25-6,000 m, minimum range—1,500 m, maximum range—10,000 m, maximum target speed at an altitude of more than 100

m—500 mps, kill probability—0.4-0.94. The SAM system is mounted on a BAZ 3937 amphibious off-road three-axle chassis.

The Ulyanovsk Mechanical Plant presented the Gang SAM System (export variant of the Buk Tactical SAM System or SA-11) that is designed to destroy high-speed maneuvering aerodynamic targets, aircraft-projectiles, and cruise missiles under conditions of a massive air raid and intense enemy electronic countermeasures and also fire support helicopters, including those hovering at extremely low altitudes. The target guaranteed kill zone is 15-22,000 meters in altitude and 3,000-32,000 meters in range. Maximum speed of approaching targets can reach 830 mps, of targets moving away—300 mps. The system supports simultaneous firing against up to six targets that are flying from any direction at various altitudes. The target kill probability is 0.7-0.9.

The system's combat elements include a command post (KP), a target detection station (SOTs), six self-propelled launchers, and six launcher-reloaders (all—on armored off-road tracked chassis that weigh 30-35 tonnes, have a maximum highway speed of 65 kph and a range of 500 km). Equipment includes a vehicle and maintenance shop, mobile automated monitoring-test equipment to inspect the surface-to-air missiles, three repair and maintenance vehicles, a SAM transport vehicle, a compressor and a truck crane (all—on ZiL-131, Ural-43202, or KrAZ-255B off-road truck chassis).

The SAM system command post has an information depiction system, a digital computer, communications encoding equipment, a data transmission device, an internal telephone communications and switching system, a speech communications system, navigation equipment, documentation and simulation equipment, and an independent electrical power source. Habitation conditions permit a crew to operate continuously for a 24-hour period.

The command post is capable of simultaneously processing information on 75 targets and simultaneously tracking 15 tracks in the automatic mode. The target detection station, equipped with a radar with a folding phased array antenna, ensures detection of airborne targets, identification of friend or foe (IFF), and transmission of information on the air situation to the system's command post. The target detection station has a digital computer, a radar interrogator, a television-optical sighting device, navigation equipment, automatic launch equipment, an electro-hydraulic servo drive, a speech, telecode, and internal communications system, and an independent electrical power source. The station provides protection from passive and various types of active jamming and can be deployed in the combat configuration in five minutes.

**Specifications of the Gang System's Target Detection Radar**

<b>Detection zone, km:</b>	
Altitude	25
Range (with zero angles of cover at target altitude of 100 m)	35
Range with target flight altitude of 1,000-25,000 m	100
<b>Detection zone for angular coordinates, degrees:</b>	
Along the azimuth	360
Along the elevation	40
<b>Resolution</b>	
Range, m	400
Angular coordinates, degrees	3-4.5

The self-propelled gun mount is capable of operating both as part of the SAM system based on target designation data and also in the independent mode in a previously assigned sector of responsibility. Firing against airborne targets can be conducted both from the mount itself and also from the PZU [launcher-reloader] assigned to it, which significantly increases the system's combat capabilities.

The SPU [self-propelled launcher] consists of the fire control radar with a jam-proof system, a radar interrogator, command and control and information processing equipment, data transmission equipment, navigation equipment, a speech and intercom system, and also an independent electrical power source.

**Specifications of the Gang System's Fire Control Radar**

<b>Target detection range, km:</b>	
At an altitude of 3,000 m	85
At an altitude of 100 m in the SDTs mode	35
At an altitude of 30 m in the SDTs mode with angles of cover of 0°	23
<b>Target lock-on range, km:</b>	
At an altitude of 3,000 m	70
At an altitude of 100 m	30
At an altitude of 30 m	20
Of a hovering helicopter at an altitude of 30 m	8-10
Minimum tracking range, km	3

In the event that its own radar malfunctions, the SOU [self-propelled gun mount] can be utilized in the firing mode with target illumination by another SOU.

There are four missiles on a self-propelled launcher which are launched at an angle. The weight of the self-propelled launcher is 32,340 kg and set up/tear down time is five minutes.

The launcher-loader is designed to launch, transport, and store missiles and also to conduct loading and

unloading work. It consists of an internal intercom and switching equipment, a speech communications and telecode communications system, a load-lifting device, an analog computer, navigation equipment, documentation equipment, and an electro-hydraulic servo drive.

Four missiles are transported on launchers and can be launched and another four missiles are carried under them on transport brackets. Self-loading time for the launcher-loader with four missiles that are on the transport brackets is 15 minutes and loading time of the self-propelled gun mount is 13 minutes.

The 9M38M1E single-stage SAM is manufactured according to a normal aerodynamic design with a low-aspect-ratio wing and has semiactive radar guidance, an autopilot, a radar fuze, a system of contact sensors, electrical equipment with a turbogenerator power source, a control surface gas feed system with a gas generator, and a solid-fuel engine.

**Specifications of the 9M38M1E SAM That Is Part of the Gang System**

Missile length, mm	3,330
Fuselage diameter, mm	400
Control surface span, mm	860
Weight of the SAM, kg	690
Weight of the warhead, kg	70
Target destruction radius, m	17
Launch ranges, km	3-32
Altitude range of destroyed targets, m	15-22,000
Maximum speed of destroyed target, mps	830

The Gang SAM System's distinctive features include its high mobility and combat survivability.

The Fakel MKB, headed by Academician P. Grushin until 1991 (V. Svetlov heads the MKB at the present time), presented information on the S-200DE (SA-5) and S-300PMU (SA-10) SAM Systems and the future S-300PMU-1 SAM System that has been developed for a PVO [air defense] system.

The country's PVO troops cover more than 400 economic and military targets on the territory of Russia (including more than 100 strategic targets) from the potential enemy's strategic offensive forces' air strikes. Sixty-five percent of the air defense weapons that previously belonged to the USSR are concentrated in Russia.

The S-200 SAM System was developed at the end of the 1960's to destroy aircraft, first of all strategic bombers. The experience of the combat employment of the S-75 SAM System in Vietnam was widely utilized during development of the system. The S-200 SAM System was supplied to Syria and employed in combat operations during the winter of 1982-1983 against Israeli and American aircraft (they were serviced by Soviet crews). In

1986, a S-200 SAM System that was serviced by Libyans participated in repelling an air raid by American aircraft against Tripoli, during the course of which the United States lost an F-111 fighter-bomber and, according to Libyan information, several other carrier-based aircraft.

The missiles that are part of the S-200DE SAM System have a semiactive radar guidance system. A battalion has 12 restrictedly mobile launchers, and missile firing preparation time is 1.5 seconds. The maximum guaranteed target kill range of a strategic bomber/AWACS aircraft/jammer aircraft is 300 km, the altitude ranges of intercepted targets—300-35,000 meters, and maximum target speed is 4,300 kph.

The S-300PMU Multichannel Mobile SAM System was accepted into the inventory in the mid-1980's and is designed to destroy enemy aircraft, helicopters, cruise missiles, and ballistic missiles at a great distance in a broad range of altitudes. The system consists of a command post, radar (mounted on MAZ off-road four-axle chassis), and 12 self-propelled launchers (each carries four missiles in a TPU [launcher-transporter]). The self-propelled launcher is manufactured in two modifications: SP85TE—trailer on a KrAZ three-axle truck and SP85SE—on a MAZ four-axle truck.

The 48N6Ye single-stage solid-fuel guided missile has a guidance system that is similar to the one employed in the Patriot MIM-104 SAM. Maximum guaranteed target destruction range is 90 km, and the range of destruction altitudes is 25-25,000 meters. The missile is launched vertically from a transport-launch canister (TPK) using a catapult and after launch the engine is canted by gas control surfaces-ailerons in any required direction depending on the position of the target.

The guided missile was developed based on the concept of guaranteed reliability, is operated in a sealed transport-launch canister, and does not require inspection or adjustment during the entire period of service.

The fire control radar is equipped with a phased antenna array with a digital beam control system that has a multiprocessor computer. During deployment in a city, forest, or rugged terrain, the radar can be raised to a great height using a special lift device that is transported on a separate trailer.

The SAM system can operate both in the air defense system radar target designation receipt mode and independently (in this case, it includes a 360° surveillance radar that is capable of detecting low-flying targets and is raised to a height of several dozen meters on a special pole).

System deployment and teardown time is five minutes and the rate of fire is five seconds. Twelve missiles can be fired simultaneously against six targets.

The future S-300PMU-1 SAM System which they plan to accept into the Russian PVO Troops inventory in 1993

was displayed at the exhibition. In contrast to the S-300PMU System, the new SAM system has an expanded range of speeds of destroyed targets (aircraft flying at speeds of up to 6,450 kph can be intercepted), the radar surveillance sector has been increased, and the maximum guaranteed kill range for aerodynamic targets has been increased to 150 km, for ballistic missiles—to 40 km.

There is a built-in simulator to train the SAM system's crews.

**Comparative Specifications of the S-300PMU, S-300PMU-1, and Patriot MIM-104 (U.S.) SAM Systems**

	Type of System		
	S-300PMU	S-300PMU-1	MIM-104
Maximum launch range, km	90	150	60
Range of target destruction altitudes, m	25-25,000	25-25,000	60-24,000
Maximum target speed, mps	—	6,450	—
Maximum SAM speed, mps	2,100	—	1,600
Number of targets fired at simultaneously	6	—	8
Number of missiles guided simultaneously	12	—	8

The 9A35M3 Strela-10M3 (Western designation SA-13) Light SAM System is designed for direct cover of troops on the battlefield and on the march from low-flying aircraft and helicopters, and also for destruction of cruise missiles and UAV's.

The SAM system mounted on an MTLB tracked armored chassis includes:

- a 9S86 zone assessment device (AOZ) that is designed for automatic determination of the position of the target relative to the borders of the missile launch zone (in a range of 450-10,000 m) and calculation of the angles of a prohibited launch that are worked out by the launcher prior to missile launch;
- a 9S16 passive direction finder (PRP) designed to detect and get an accurate bearing on airborne targets that are flying with turned-on onboard pulse radio-technical systems (a 360° surveillance sector along the azimuth and an elevation of 40°);
- an 1RL246-10-2 ground-based radio interrogator (NRZ) that is designed to determine whether an airborne target is friend or foe at a range of up to 12,000 meters and altitudes of 25-5,000 meters;
- a 9V179-1 reception and target designation device (APTs) and a 9V180 target designation realization device (ARTs) that is designed for centralized command and control of the combat operation of the systems from mobile command and control facilities that are equipped with a standardized data transmission device (ASPD-U);

- a 9V38M3 projectile launch device (AZS) that serves for prelaunch preparation of missiles in the manual and automatic mode of switching posts (emergency missile launch and the capability to train crews with monitoring of operator actions has been provided for. Sound and light signals are given to the operator as an indication of fulfillment of operations during combat work).

Four missiles ready for combat are on the launcher in transport-launch canisters and another four SAM's are carried in the combat vehicle. The missile operates in the autonomous mode, guiding itself according to photo contrast or target IR radiation. Firing is conducted in place or at short halts. The crew consists of a commander, an operator, and a driver-mechanic. An RPK (7.62 mm) machine gun is attached to the saddle in front of the commander's hatch on the hull of the combat vehicle for self-defense of the SAM system.

The 9A35M3 Strela-10M3 SAM System is being widely exported to foreign countries.

#### Specifications of the Strela-10M3 SAM System

Weight of the system	12,300 kg
Maximum target destruction range	5,000 m
Minimum target altitude	25 m
Maximum target altitude	3,000 m
Temperature range of combat employment	-50 to +50°
Range of launcher guidance angles	
Along the vertical	-5 to +80°
Along the azimuth	360°
Speeds of launcher guidance	
Along the vertical	0.3-50° per second
Along the azimuth	0.3-100° per second
ZSU (antiaircraft artillery system—AAA) maximum speed:	
Along roads	61.5 kph
Afloat	5-6 kph
Range	500 km

#### Dual and Multipurpose Tactical Missile-Artillery Systems

The 2K22M Tunguska Regimental Air Defense System presented by the Ulyanovsk Mechanical Plant is the first series-produced system in the world that permits the destruction of targets by both SAM's and artillery fire. The system is capable of conducting fire both on the move and from short halts and can destroy various airborne and ground-based targets, including hovering helicopters. The kill zone of one ZSU (antiaircraft artillery system) while firing the automatic antiaircraft guns is 0-3,000 in altitude and 200-4,000 m in range and 15-3,500 and 2,500-8,000 m, respectively, while firing a 9M311 SAM.

The system consists of combat weapons (a battery of six SAM's) and maintenance equipment (six TZM's on KamAZ-43101 chassis, two repair and maintenance vehicles on Ural-43203 chassis, a maintenance vehicle on a Ural-43203 chassis, a maintenance shop on a ZiL-131 chassis, and automated monitoring-test equipment on a GAZ-66 chassis).

The 2S6M antiaircraft artillery system is manufactured on an armored tracked chassis and is designed to destroy airborne targets using artillery weapons in place, at short halts, or while moving under various weather conditions at any time of day, and also using missiles in place or at short halts under conditions of optical visibility. Effective firing by the automatic antiaircraft artillery guns is possible against ground troops and surface targets at a range of up to 2,000 meters.

The ZSU system consists of a radar, a digital computer, an optical gunsight with a guidance and stabilization system, hydraulic laying drives, two twin-barrel 30 mm automatic guns, eight launchers for installation of 9M311 SAM canisters, navigational equipment, a pitch and course angle measurement system, internal and external communications equipment, a life-support system, an electrical power supply system, and a tracked chassis.

#### Comparative Specifications of the Tunguska SAM System and Other Similar Systems

	Type of System			
	Tunguska	Shilka	Gepard (FRG)	Roland (FRG/France)
Length of mount, m	7.93	6.54		
Width of mount, m	3.24	2.95		
Height of mount, m	4.02/3.36	2.25		
Weight of loaded mount, kg	34,000	20,500	47,300	32,000
Radar target detection range, m	18,000	20,000	15,000	15,000
Target tracking range, m	13,000	—	—	—
Number and caliber (mm) of guns	2 x 30	4 x 23	2 x 35	none
Number of missiles	8	none	none	10
Reaction time, seconds	10	—	—	—
Airborne target destruction range, km:				
By guns	0.2-4.0	2.5	4.0	—
By missiles	2.5-8.0	—	—	0.5-6.2
Destruction altitude, km:				
By guns	0-3.0	—	—	—

# Comparative Specifications of the Tunguska SAM System and Other Similar Systems (Continued)

	Type of System			
	Tunguska	Shilka	Gepard (FRG)	Roland (FRG/France)
By missiles	0.015-3.5	—	—	0.02-3.0
Effective kill range of ground-based targets, m	2.0	2.0	—	—
Maximum speed of an airborne target, mps	500	—	—	500
Combat effectiveness:				
For guns	0.6	—	—	—
For missiles	0.65	—	—	—
Total rate for fire from guns, rounds per minute	5,000	3,400	1,100	—
Maximum speed, kph	65	44	65	62

The system consists of a 9M311 guided missile that is designed to destroy airborne targets in the range of speeds from 0-500 mps with a semiautomatic radar guidance system with manual target tracking and the system automatically brings the missile to the sighting line based on signals transmitted over a radio channel.

The SAM consists of an onboard electronic device, gyroscope coordinator, control surface drive unit, a tracker, a power unit, a warhead, a proximity target sensor, and separating engine unit (the missile moves toward the target based on inertia after the SAM's speed run and separation of the first stage).

## Specifications of the 9M311 SAM

Missile length, mm	2,562
Fuselage diameter, mm	170
Wingspan, mm	225
Missile weight, kg	42
Weight of missile in canister, kg	37
Warhead weight, kg	9
Minimum range, m	2,500
Maximum range, m	8,000
Minimum destruction altitude, m	15
Maximum destruction altitude, m	3,500
Maximum missile speed, mps	900
Average missile speed, mps	600
Maximum deviation (operating radius of the proximity fuze sensor, m)	5

In contrast to similar Western systems, Tunguska corresponds to cost-effectiveness criteria to a greater degree because the most expensive elements in its design (the SOU [self-propelled gun mount] and the tracked armored chassis) are used to simultaneously support combat employment of the artillery and missile systems (in the FRG army the Roland SAM and the Gepard AAA systems and in the American army the Chaparral SAM and the Vulcan AAA systems are used simultaneously to support air defense at the battalion level).

The 9P149 Shturm-S System is designed to combat both tanks and other mobile armored targets and also low-flying, low-speed, airborne targets (helicopters and UAV's).

The mount is manufactured based on the MTLB amphibious, armored, tracked transporter. In the travel configuration, the launcher is retracted inside the hull. Reloading missiles is carried out automatically. The multipurpose 9M114 guided missile that is part of the system is manufactured according to a canard design with folding PGO [foreplanes] and wing (the latter has a semicircular shape and is pressed against the missile's cylindrical fuselage in the nonoperational state). It has a launch booster that ensures the missile exits the transport-launch canister, which is manufactured from fiberglass.

It has a semiautomatic radio command guidance system with an IR missile tracking system that has high jam-proofing (two codes and five fixed frequencies are employed to guide a missile).

## Specifications of the 9M114 SAM

Missile length	1,830 mm
Caliber	130 mm
Missile weight	35.0 kg
Weight of transport-launch canister with missile	46.5 kg
Maximum launch range	5,000 m
Maximum airborne target destruction altitude (launch—at sea level)	3,000 m
Average missile cruising speed	350-400 mps
Armor-penetrating capability	560 mm
Launch time (from the moment the combat button is pressed until the missile begins to move)	1 second
Temperature range of combat employment	-50-+50 °C
Period of guided missile storage in transport-launch canister	10 years

**Specifications of the Shturm-S System**

Crew	2 men
Weight of system	12,300 kg
Basic load	12 guided missiles
<b>Maximum speed of targets being destroyed:</b>	
Flank	60 kph
Frontal	80 kph
Angles of horizontal guidance	-85°-+85°
Angles of vertical guidance	-15°-+15°
Maximum speed of the system along roads	65 kph
Operating range based on fuel	500 km

Development of the Shturm System was preceded by work on the development of antitank missile systems [ATGM] that began in the USSR in the 1950's (similar work began somewhat later in France, where they utilized German ATGM development experience at the end of World War II). Based upon primary specifications, domestically produced ATGM's are close to similar foreign-designed systems.

**Specifications of ATGM's in the Armies of the CIS Countries and of Foreign-Developed ATGM's**

Type of ATGM	Year Accepted into Inventory	Range of Launch Altitudes, m	Maximum speed, mps	Armor-Penetrating Capability, mm
Fleyta	1968	350-2,500	150	650
Malyutka	1968	75-4,000	120	550
Fagot	1973	70-2,500	185	450
Konkurs	1974	75-4,000	250	650
Skorpion	1978	1,000-5,000	450	600
Metis	1979	50-1,000	180	500
Dragon (U.S.)	1968	30-1,000	110	430
TOW (U.S.)	1968	65-3,750	300	500
Hellfire (U.S.)	1980	7-6,000	300	500
Milan (FRG/France)	1972	30-2,000	200	550
Hot (FRG/France)	1976	75-4,000	260	700

Self-propelled artillery, which has been undergoing a process of rapid improvement both in our country and also abroad in recent times, is one of the most effective weapons to combat enemy tactical SAM's and ATGM's.

The 2S19 Msta 152 mm self-propelled howitzer on a tracked chassis that has been standardized with the chassis of the T-72 and T-80 medium tanks and is equipped with a V84A 780-horsepower multifuel engine

was displayed at the exhibition. The self-propelled artillery piece was developed under the leadership of General Designer Yu. Tomashov at the Uraltransmash Production Association, was accepted into the inventory in 1989, and is manufactured at a plant in Sterlitamak.

The self-propelled artillery piece includes the 2A64 gun; a PZU-5 anti-aircraft gun mount with a Utes NSVT 12.7 mm anti-aircraft machine gun that has remote control from the turret; an automatic loader with an automatic program to feed rounds that permits loading to be carried out from any angle of elevation of the gun; mechanization of ammunition feeding from the ground; an underwater tank driving equipment kit; a built-in bulldozer blade that ensures rapid preparation of firing positions; a filtering-ventilation unit; and a thermal smoke device to create a camouflage smoke screen. The elevation of the gun during firing is adjusted without the participation of the loader (the loader controls aiming only along the azimuth). The Msta self-propelled artillery piece can utilize all types of organic munitions, including precision-guided projectiles.

**Specifications of the 2S19 Msta Self-Propelled Artillery Piece**

Weight of the system in the combat configuration	42,000 kg
Crew strength	5 men
Crew strength when firing from the ground	7 men
Maximum speed along roads	60 kph
Range based on fuel	500 km
Length of negotiated water barriers (using the underwater tank driving equipment)	1 km
Depth of negotiated water obstacles (with the underwater tank driving equipment)	5 meters
Time to convert the system from the travel to the combat configuration	1-2 minutes
Maximum firing range (conventional projectile)	24,700 m
Maximum aimed firing range from the anti-aircraft machine gun	2,000 m
Angle of horizontal firing	360°
Angle of laying along the vertical	-4°-+68°
Maximum rate of fire of the gun	7-8 rounds per minute
Maximum firing mode:	
During the first hour	100 rounds
During each subsequent hour	60 rounds
Rate of fire of the anti-aircraft machine gun	700-800 rounds per minute
Basic load:	
152 mm projectiles	50
12.7 mm projectiles for the machine gun	300

Joint work in the sphere of self-propelled artillery is one of the possible directions of the Russian defense industry's international cooperation. In 1992 the French firm

GIAT, which specializes in the production of artillery systems, demonstrated a model of its F1 (155 mm) caliber self-propelled automatic howitzer manufactured on a T-72 tank chassis (they were produced or are being produced in the USSR, Czechoslovakia, Poland, India, and Yugoslavia). In the opinion of foreign experts, the F1 howitzer is one of the best weapons of this class in the West and approaches, based on its specifications, the 2S19 self-propelled artillery piece (the weight of the F1 self-propelled artillery piece on an AMX-30 tank chassis—42 tonnes, speed—60 kph, firing range of a conventional round—23.5 km, maximum rate of fire—8 projectiles per minute, carried basic load—42 projectiles, crew—4 men). More than 400 GIAT systems are in the inventories of the armies of France, Iraq, Kuwait, and Saudi Arabia.

The Krasnopol Guided Artillery Projectile with a semi-active laser guidance system was developed in Russia for firing from 152 mm guns. The projectile is designed both for firing from the most modern guns like the 2S19 Msta and 2S5 Giatsint and also from the older 2S3M and D-20 self-propelled and towed artillery systems. It can destroy with a high probability (0.7 when firing at a distance of 18,000 m) small mobile and fixed targets (tanks, motor vehicles, artillery pieces, fortified firing positions, etc.). So, during the course of a test firing, a tank that was moving at a speed of 36 kph was destroyed at a distance of 14,000 m.

A portable laser target designator installed on a tripod (installation of the illumination system on a helicopter, UAV, etc., is possible) is used for illumination. They managed to destroy three different targets in 30 seconds during test firings using one target designator. During firing at maximum range, the projectile's seeker is capable of locking on to targets in a radius of 1 km that are illuminated by the laser. The capability has been provided to fire at wind speeds of 25 mps. During use of a 152 mm guided projectile in contrast to a conventional projectile of the same caliber, the expenditure of projectiles is reduced by a factor of 40-50 and the time required to destroy a target is reduced by a factor of 3-5.

The 9K112/9M117 Kobra ATGM (Western designation AT-8) was developed in 1981 for firing from 125 mm tank guns at a range of 100-4,000 m. The missile has a radio command guidance system and is fired from T-64B, T-64B1, T-64B1K, T-80, T-80B, and T-80BVK tank smoothbore guns.

The 9K116/9M117 Bastion ATGM (AT-10) was developed in 1985 and is designed to arm tanks and BMP's [armored infantry vehicles] and has a 100 mm gun (the missile is part of the basic load of the T-55AM2P, T-55AM2B, and T-55AMV tanks and the BMP-3; a special variant of this ATGM has been developed to arm the T-62M tank with a smooth bore gun).

The 9K120/9M119 Svir ATGM (Western designation AT-11) with a laser beam guidance system was developed in 1986. The missile attains speeds of up to 800

mps and is capable of penetrating 700-800 mm thick armor and is part of the basic load of the T-72V, T-72S, T-80U, and T-80UD tanks.

The Kastet ATGM was developed for firing from the MT-12 (100 mm) smoothbore towed antitank gun.

At the present time, foreign tanks do not have similar weapons and their development is not being conducted (the Shillelagh ATGM, which was launched through the barrel of a special short gun—a 155 mm launcher—was accepted into the inventory of the M60A2 medium tank and the Sheridan M551 light tank in the United States in 1967). However, the low ballistic specifications of the gun, which is incapable of conducting effective combat with enemy tanks using conventional projectiles at short and medium ranges, resulted in the rejection of this system. Development of a similar system in France also ended unsuccessfully.

#### Specifications of ATGM's That Are Fired From Tank Guns

Type of ATGM	Year Accepted Into Inventory	Launch Ranges, m	Maximum Speed of Missile, mps	Armor-Penetrating Capability, mm
Kobra	1981	1,000-5,000	400	700
Bastion	1985	100-4,000	375	550
Svir	1986	100-4,000	800	650
Shillelagh (U.S.)	1967	?-3,000	690	500

#### Shipborne Antiaircraft Missiles

A significant amount of the exhibition's materials were concerned with shipborne antiaircraft missiles.

The Altair NPO, the general developer of maritime surface-to-air missile systems, presented information on the Shtil Medium-Range SAM System (Western designation SA-N-7) designed for air defense of ships or ship formations from antiship missiles and aircraft simultaneously attacking from different directions. It has the capability to conduct fire against surface targets.

The SAM system can be mounted on ships with a displacement of 1,500 tonnes or more, has a modular design that ensures great combat survivability, simplicity of operation, and the capability for the customer to acquire the configuration he needs, with the number of channels, rate of fire, and basic load depending on the displacement of the ship-launch platform and the conditions of its combat employment.

The system operates with a ship three-dimensional [3-D] 360° surveillance radar that transmits current secondary information and can additionally have a built-in system of television-optical sights.

High automation of computer and execution devices, expansion of the missile fire zone from aimed launchers

with regard to launch sectors restricted by the ship's superstructures, and stable operation of the system with seas of up to sea state five are ensured in the SAM system.

The system underwent testing on the Provornyy Design 61 BPK [large antisubmarine warfare ship], which was reequipped for this purpose in the mid-1970's, and at the

present time is installed on Sovremennyy Class destroyers (the first ship of this class entered the line in August 1980).

The Shtil Single-Stage Solid-Fuel SAM Missile with a semiactive radar guidance system is standardized to a significant degree with the Gang/Buk SAM Systems missile. The SAM has a 70 kg warhead, a radio fuze, and is capable of maneuvering with a G-load of 20.

#### Specifications of the Shtil SAM System

Number of targets being fired at simultaneously (depending on configuration)	2-12
Target bearing zone	360°
Target elevation zone (without taking into account operation of ship radar)	0-70°
<b>Target flight altitude range:</b>	
Aircraft	15-15,000 m
Antiship missiles	10-10,000 m
<b>Maximum target speeds (depending on altitude)</b>	
Aircraft	420-830 mps
Antiship missiles	330-830 mps
Reaction time (in alert mode)	16-19 seconds
<b>Operating range:</b>	
Against aircraft at altitudes above 1,000 m	3,500-25,000 m
Against aircraft at altitudes less than 1,000 m	3,500-18,000 m
Against antiship missiles	3,500-12,000 m
<b>Probability of kill using a two missile salvo (taking into account reliability):</b>	
Of an aircraft	0.81-0.96
Of an antiship missile	0.43-0.86
Wave range	In the centimeter band

#### Specifications of the SAM that is part of the Shtil SAM System

Missile length	5,550 mm
Missile diameter	400 mm
Control surface span	860 mm
Missile weight	690 kg
Warhead weight	70 kg
Maximum Mach of the missile	3

The missile is launched from a surface launcher designed for one missile ensuring a high rate of fire. The weight of the launcher (without the missile) is 30 tonnes, the area of the magazine is 5.2 x 5.2 m, and the depth of the magazine is 7.42 m.

A high degree of modularity (numbers of configurations) of the design permits the system to be accommodated on ships of various classes and displacements (a design 61 model large antisubmarine warfare ship with two launchers mounted on a single gun platform on a tank was demonstrated on a stand at the exhibition).

**Specifications of Different Variants of the Shtil SAM System**

	Number of configuration							
	1	2	3	4	5	6	7	8
Number of channels (antenna masts)	2	4	4	6	8	8	10	12
Rate of fire, seconds	12	12	6	6	6	4	4	3
Basic load (number of launchers)	1	1	2	2	2	3	3	4
<b>Area of instrument posts, m<sup>2</sup>:</b>								
Central	29	32	34	37	40	40	43	52
General (with spare parts kits and assemblies)	63	72	88	98	106	119	120	156
<b>Weight, tonnes:</b>								
Of the antenna masts	2.4	4.7	4.7	7.1	9.4	9.4	11.8	11.8
Total (without basic load)	49	56	89	96	103	134	138	180
Personnel, men	11	13	15	19	21	23	27	32
Energy consumption, kw	130	180	240	320	370	400	450	530

The Klinok Multichannel All-Weather Independent Surface-to-Air Missile System (Western designation SA-N-9) is designed for self-defense of combatants and civilian ships from massive attacks of low-flying antiship missiles and other unmanned and manned aircraft that operate at low and medium altitudes and also ships (including wing-in-ground effect vehicles).

The SAM system is capable of simultaneously destroying up to four targets in a spatial sector of 60 x 60° while being aimed in a circle. Furthermore, the system is capable of controlling the fire of 30 mm automatic guns.

Its own airborne target radar detection systems provide the system with complete independence from ship radars and the capability for operations in the most complex situation. Furthermore, information that is received from any other target designation systems can be utilized.

The phased array antennas with electronic beam control and a high-speed computer system with developed software based on processing information in real time that uses a universal system of servicing subscribers is the basis of the system's multichannel capability: with sequencing, interrupts, and priorities.

The Klinok SAM System has high automation of combat operations—from the detection of targets to their destruction, low reaction time, and a high rate of fire. The system has an adequate depth of automated functional control and is reliable in operation. The television-optical target tracking devices built into the antenna mast increase its jam-proof feature under conditions of intensive countermeasures.

The underdeck launcher has three to four drum-type launch modules. There are eight transport-launch canisters with missiles in each module.

The SAM that has been standardized with the Tor Tactical SAM System has been utilized in the Klinok SAM System. Missile launch is vertical and is carried out using a catapult. After the missile leaves the launcher, a gas-dynamic system is set into motion that inclines the missile in the direction of the target. The engine is started at a safe altitude after the SAM is turned toward the target. Detonation of the high-explosive-fragmentation warhead is carried out according to the command of the pulse radio fuze in direct proximity to the target. The destruction of maneuvering and straight-flying high-speed targets is ensured thanks to the high speed of the missile's flight.

The missile is transported and stored in a transport-launch canister that ensures its storage, constant combat readiness, convenience while being transported, and safety while being loaded into the launcher. The missile needs to be inspected once every 10 years of storage.

According to the developing firm, there are no other self-defense SAM systems similar to the Klinok System. It can be installed on combatants and ships with displacements of 800 tonnes or more. The system's modular design principle suggests different variants for its installation. The SAM system can be operated in various climactic conditions and can destroy targets under seas of up to sea state five. The crew strength of the Klinok System is 13 men.

**Specifications of the Klinok Shipborne SAM System**

Maximum detection range of targets at an altitude of 3,500 m (under autonomous operation of the system)	45,000 m
Operating band	K (X, I)
Reaction time (depending on radar mode)	8-24 seconds
Time to bring system to combat readiness:	
From a cold state	3 minutes
From an alert mode	15 seconds
Rate of fire	3 seconds
Minimum target destruction range	1,500 m
When the 30 mm artillery mount is included	300 m
Maximum target destruction range	12,000 m
Minimum target destruction altitude	10 m
Maximum target destruction altitude	6,000 m
Speed of targets	0-700 mps
Number of targets being fired at simultaneously in a spatial sector of 60 x 60°	4
Number of missiles being guided simultaneously	8
Basic load	24-64 SAM's
Missile weight	165 kg
Warhead weight	15 kg
System weight (without the basic load)	41,500 kg
Required space for the system	113 m <sup>2</sup>
Required power	220 kw per hour

Admiral of the Fleet of the Soviet Union Kuznetsov, Admiral of the Fleet of the Soviet Union Gorshkov, and the Novorossiysk heavy aircraft-carrying cruisers, Kirov Class nuclear missile cruisers, Udaloy Class large antisubmarine warfare ships, and Neustrashimyy Class escort vessels are armed with the system.

The Rif SAM System, which is a development of the Fort Shipborne SAM System (Western designation SA-N-6), was developed at the Altair NPO for destruction of aerodynamic and ballistic targets at long range from the defended ship. The 48N6Ye missile that is part of the system has been standardized with the PVO strany S-300PMU SAM System.

The system can be accommodated on ships with a displacement of 5,000 tonnes or more. The SAM's are located in vertical underdeck launchers (a basic load of 48 or 64 guided missiles depending on system configuration). The rate of fire is three seconds. The SAM system is capable of simultaneously tracking 12 targets and intercepting six targets. Maximum airborne target destruction range is 90 km. The missile is equipped with a powerful 130 kg warhead and can be employed against both airborne and surface targets.

Tests of the Fort SAM System were conducted on the Azov Large Antisubmarine Warfare Ship (Nikolayev

Class) in the Black Sea Fleet. Kirov Class nuclear missile cruisers and Slava Class missile cruisers are equipped with Fort or Rif systems.

**Multiple Rocket Launcher Systems**

Rockets that are part of the latest generation multiple rocket launcher systems were displayed at the exhibition.

The Prima (122 mm) Multiple Rocket Launcher System is designed to replace the Grad Multiple Rocket Launcher System and is also manufactured on a Ural motor vehicle chassis but has an increased number of launchers from 40 to 50. Remote introduction of the time of separation of the warhead in flight to increase the shrapnel kill area has been provided for. The operating temperature range is +/-50 °C.

The Uragan Multiple Rocket Launcher System (on a ZiL-135 chassis) has rockets with high-explosive and fragmentation warheads and also warheads that are loaded with antitank and antipersonnel mines. One rocket can carry 30 cluster elements, 24 antitank mines, or 312 antipersonnel mines. The firing of rockets singly or in salvos is possible. The area destroyed by a salvo from one launcher is 426,000 m<sup>2</sup>, the duration of one salvo is 20 seconds, and the combat vehicle's range is 570 km. The system includes a transloader vehicle. According to its specifications, the Uragan Multiple Rocket Launcher System is close to the American MRLS Multiple Rocket Launcher System.

At the present time, the Smerch Multiple Rocket Launcher System is the most powerful system of this class in the world.

The system consists of combat and transloader vehicles, each of which is a self-propelled unit based on a MAZ-534M four-axle motor vehicle chassis. An artillery section with 12 launchers is mounted on a combat vehicle and the transloader vehicle transports 12 projectiles and is equipped with a crane. The Smerch Multiple Rocket Launcher System is manufactured by the Perm Machine-building Plant. The fire control system supports salvo or single rocket launches.

Based on the assessments of the developing firm, the Smerch Multiple Rocket Launcher System exceeds other countries' latest salvo fire systems, including the American MLRS system that was employed in the war against Iraq in 1991. Superiority over similar foreign systems is noted not only based on the specifications of the artillery section but also based on the quality of the automated fire control system that is manufactured by Tomsk's Kontur Production Association. The automated control system links several command-staff vehicles that are at the disposal of the commander, unit chief of staff, and subunit commanders. Each of these vehicles, which are based on a KamAZ-4310 motor vehicle chassis, has radio equipment that supports communications in the UHF band at a range of up to 50 km and in the HF band—up to 350 km. The rocket that is part of the system is configured with various types of warheads, including cluster warheads with 12 elements. The time required to bring the multiple rocket launcher system to combat readiness after a march is three minutes.

**Specifications of the Multiple Rocket Launcher Systems That Were Displayed at "Mosaeroshow-92" and Similar Foreign Systems**

	Type of Multiple Rocket Launcher System					
	Prima	Smorch	Uragan	MLRS (U.S.)	Lars (FRG)	RM-70 (Czechoslovak SSR)
Caliber, mm	122	220	300	240	110	122
Missile length, mm	3,037	5,178	7,600	3,960	2,260	3,226
Number of launchers	50	16	12	12	36	40
Missile weight, kg	70	280	800	310	34	77
Warhead weight, kg	—	51	300	139	16.2	—
Minimum firing range, km	5	10	20	—	6.5	—
Maximum firing range, km	20.5	35	70	30	25 *	20.5
Area of destruction by one salvo, thousands of m <sup>2</sup>	190	426	672	—	—	—
Duration of salvo, seconds	30	20	38	—	18	—
Range of combat vehicle, km	990	570	900	485	—	—
Base	Ural	ZiL-135	MAZ-634	SPLL	Ma Jupiter	—
Wheel formula	3 x 3	4 x 4	4 x 4	tracked	3 x 3	4 x 4

\* Firing range of latest modification of rocket. Multiple rocket launcher systems were previously equipped with missiles with ranges of 14.5 and 19 km.

## 8. Electronics and Reconnaissance Equipment

The Nizhny Novgorod Television Plant displayed the 1L13-3 Metric Band Early Warning Radar that is designed for use in an air defense system. The radar is capable of detecting and determining the coordinates (azimuth and range) of airborne targets at great range under conditions of intensive electronic countermeasures and of determining whether they are friend or foe and transmitting information on the air situation to the command post via landline and radio communications channels.

The radar can be utilized as part of automated air defense and air force command and control systems (including those that are part of rapid deployment forces) and also independently. The entire radar system can be accommodated on four chassis and consists of:

- a device module (weighing 12 tonnes and mounted on a Ural motor vehicle);
- a trailer with a 2PN4-M with an NRZ [ground-based radio interrogator] radar antenna (weight five tonnes);
- a primary antenna module with an APU cabin (Ural 11.5 tonne); and,
- an ED-2X30-T30P-3RA electrical power generator (KamAZ 12 tonne).

An additional configuration of the radar with a removable command post with two operator workstations that is mounted in a K1.P4 van is possible.

Speed along roads is 75 kph, maneuvering is possible on areas without roads, and transport is also possible by rail, water, and air. Deployment time from the travel configuration and teardown totals 45 minutes and, in the process, no special preparation of the area is required to install the radar.

The 1L13-3 Radar equipment module consists of a transceiver, an operator workstation, computer equipment, an information processing computer, built-in equipment monitoring and malfunction isolation equipment, a landline telecode communications system, two external radio communications sets, a simulator, and an IFF device.

The 1L13-3 Radar that is mounted on a separate three-axle trailer consists of a flat antenna array, an electric drive with a support-turning device, a deployment mechanism from the travel configuration, and canisters with an HF receiver and a removable protective cover. The ground-based radio interrogator antenna trailer consists of an antenna, a synchronized servo drive, and a spare parts kit. The radar is capable of detecting F-117A class low-observable aircraft.

The mobile electrical power generation unit consists of two 30-kw diesel generators, automated and remote control equipment, and a panel for connection to an industrial grid.

The more powerful 55Zh6-1 Metric Band 3-D Radar developed by the same enterprise is designed for effective detection and determination of the coordinates of modern and future aircraft, helicopters, cruise missiles, aerostats, and also other aircraft under conditions of intensive reflections from ground clutter and man-made electronic countermeasures.

The radar can be operated under any meteorological conditions and in any climactic zones. The radar is capable of operating both as part of automated command and control systems and independently. Transportation of the radar is carried out by motor vehicle, rail, air, river, and maritime transport. Information on the radar's display can be recorded by the objective monitoring device. The system consists of an antenna-mast device (AMU); the antenna that is attached to the mast

has a 16 x 3.24 m phased array. The vertical position of the mast is ensured by guy cables. The design of the antenna-mast device ensures its operability under conditions of an ice storm and wind loads of up to 35 mps.

The radar's transmitter and maintenance area are located in KPP-15 vans and include a radar reception device, a specialized microcomputer, two operator workstations, a function monitoring and diagnostics device, an IFF device, and also a simulator.

The transfer device contains a radar operating mode control device and three displays. The transfer indicator device equipment is designed to control and depict radar information at air traffic control facilities with a distance of up to 1,000 m via a cable line (it is possible to increase the number of operator workstations to five and to connect a second 55Zh6-1 Radar).

The 50E6 Electrical Power Supply System consists of two diesel electrical power generators and a distribution-transformer device (it is possible to control the operating modes and turn the generator on from the maintenance area).

Specifications of the 55Zh6-1 and 1L13-3 Radars

	Type of radar	
	55Zh6-1	1L13-3
Frequency range	Metric	Metric
<b>Field of surveillance:</b>		
Range, km	500	300
Altitude, km	40	27
Azimuth, degrees	360	360
Elevation, degrees	16	25
<b>Fighter aircraft detection range:</b>		
At an altitude of 10 km	300	230
At an altitude of 20 km	400	
At an altitude of 27 km		300
Upper detection limit of a fighter class target, km	40	27
Ground clutter suppression coefficient, db	40	
<b>Accuracy of determination of target coordinates:</b>		
Range, m	500	600
Azimuth, minutes	24	60
Altitude, m	850	
Data transmission rate, seconds	10.2	10.2
Required power, kw	150	29
Turn on time, minutes	3.5	3.0
Deployment time, hours	22	0.75

The 35N6 2-D Radar was developed to replace the P-15 Tropa and P-19 radars. It is designed to detect targets with a reduced RCS (cruise missiles, UAV's, and light motor aircraft) that are flying at low altitudes at a range of speeds from extremely low to supersonic. Work on the development of the radar was begun in 1983 under the leadership of V. Kopeykin and Yu. Stepanov headed the program

after him. The first models of the new radar began to enter RTV [radiotechnical troops] units in 1986.

The 35N6 Radar permits the detection of small targets in the background of intensive reflections of the underlying surface, ground clutter, and hydrometeorological formations. The three-channel moving target selection system permits targets to be effectively isolated from interference.

The radar is mounted on two KamAZ motor vehicles: the electronic equipment (transmitter, receiver, monitoring and communications equipment, operator workstation, etc.) are located in the first KamAZ and the second KamAZ carries the antenna, a diesel electrical power generator for an independent power source, and an external power grid frequency transformer. It has a reserve power generator on a single-axle trailer. The operator's portable workstation can be deployed at a distance of up to 300 meters from the radar.

The radar can operate both with the main antenna and with an antenna that has been installed on a light mobile mast with a raised height of up to 50 meters. This permits the radar to be deployed in a forest, city, or on rugged terrain.

The 35N6 Radar's mean time between failures is 300 hours, and operation is possible at temperatures from -50 to +50 °C and at wind speeds of up to 25 mps in snow, ice storms, and rain. During the development of the radar, an adequately high level of comfort for the operators was ensured: the noise level has been reduced, there are air heating and cooling systems, and individual and sanitary ventilation. The absence of high-voltage power sources promotes work safety for the crew. The effect of X-rays and SHF radiation on people has been excluded.

During tests the radar successfully detected small light-motor aircraft piloted by test pilots who attempted to penetrate the air defense line at extremely low altitude.

The possibility of developing a specialized coastal radar based on the 35N6 radar to detect ships with small RCS's is being studied.

#### Specifications of the 35N6 Radar

Frequency range	decimetric
Detection range	5-150 km
Maximum target detection range	6 km
360° surveillance period	5 and 10 seconds
Aircraft detection range (depending on RCS):	
At an altitude of 100 m	32-58 km
At an altitude of 1,000 m	95-105 km
Suppression coefficient of reflections of ground clutter	53 db
Average restoration time	less than 30 minutes
Turn on time	less than 3.3 minutes
Deployment time during operation with an organic antenna	less than 20 minutes
Operational crew (one shift)	2 men

The 83M6Ye Command and Control Equipment System was developed at Fakel MKB for command and control of S-300PMU, S-300PMU-1, S-200DE, and S-200VEV SAM System formations (up to six SAM systems). The system consists of a 64N6Ye Radar with a phased array

antenna and a 64K6Ye Command Post manufactured on four-axle off-road wheeled chassis. It provides simultaneous tracking of up to 100 target tracks at a range of up to 300 km at a target speed of up to 10,000 kph of targets flying in dense combat formations and automatic lock-on of separating targets.

The Proton MZ offered the Baykal-1E Surface-to-Air Missile Unit Command Post that is manufactured on a MAZ off-road four-axle motor vehicle chassis. The command post is designed for command and control of combat operations of a surface-to-air missile unit that consists of long-, medium-, and short-range SAM systems.

#### Specifications of the Baykal-1E Command Post

Number of airborne targets being processed simultaneously	80
Number of ZRS's (SAM's) being guided simultaneously	4
Number of SAM systems being controlled simultaneously	12
Number of firing channels being controlled simultaneously	144
Number of automated workstations	2-5
Deployment and teardown time, minutes	5
Time to bring system to combat readiness, minutes	3
Operating limits:	
Range, km	1,200
Altitude, km	102.4
Maintenance personnel	5

The Polyana-D4 Automated Missile Brigade Command and Control System is designed for command and control of S-300V and Gang SAM System combat operations. The system consists of the MP-06RP staff vehicle, the MP-02R staff vehicle, a maintenance vehicle, an MP-45 ZIP [spare parts kit], and two ED 2X30-T4001RAM portable electric generators. The system was accepted into the inventory in 1985 and has been in series production since 1987.

#### Primary Specifications of the Polyana-D4 Automated Command and Control System

Number of battalions being controlled	4
Total number of targets being processed	up to 270
Number of depicted targets	up to 80
Number of targets being transmitted to a battalion	up to 20
Deployment time, minutes	35
Crew	13

Krasnogorsk Optical-Mechanical Plant presented information on stands about aerial cameras that it produces that are installed on a number of reconnaissance aircraft, specifically, on the Su-24MR. The specifications of the AK-108F oblique, horizontally placed reflex still camera,

the A-84 panoramic aerial rotating lens cyclical camera, the AS-707 four-channel spectrozonal aerial camera, and

the AP-402M panoramic prism cycle-less aerial camera are cited below.

	AK-108F	A-84	AP-402M	AS-707
Lens focal length, mm	1,800	300	90.5	140
Lens aperture ratio	1:5-1:22	1:4.5-1:22	1:3.5-1:22	1:2-1:22
Frame size, mm	180 x 180	118 x 748	68 x 285	180 x 180
Width of the strip in fractions of altitude	0.1-21.4	6	12	0.5
Aerial photographic film:	isopanchrom	isopanchrom	isopanchrom	MSh-4
Length, m	240	480	480	240
Width, mm	190	130	80	190
Weight of the flight system, kg	580	130	62	100-208
Interval of photography, seconds	1.3-20	1-17	0.24-4.25	0.5-10
Resolution for terrain/seconds of distance, m/km	1/100	0.4/10	0.3/0.4	0.3/1
Altitude of photography, m	500-28,000	1,000-20,000	100-1,000	50-10,000

#### 8. Business Results of the "Mosaeroshow-92" Exhibition

The "Mosaeroshow-92" Exhibition permitted Russian experts to expand business contacts with foreign partners. A number of contracts were signed with foreign and domestic aircraft companies.

The managers of the OKB imeni A.I. Mikoyan conducted preliminary negotiations with the British firm GEC Avionics on the possible large-scale modernization of the avionics of MiG-21 aircraft that are widely operated in the world; signed an agreement on the creation of a joint venture with a German firm, the tasks of which will be the organization of assistance in the operation of the MiG-29's that are in Germany's inventory; and conducted preliminary negotiations on the sale of MiG-29's to Malaysia, and MiG-29's and MiG-31's to Portugal, South Korea, and Switzerland. Attempts are continuing to convince Germany to purchase an additional number of MiG-29 aircraft in an improved variant instead of the West European EFA fighter aircraft.

The OKB imeni P.O. Sukhoy also conducted negotiations with South Korea with regard to a possible sale of Su-27 fighter aircraft; it signed a protocol on intentions with Erbas Industries on certification of the Su-26 sports-acrobatic aircraft in France; and signed a contract with the French firm Thomson on cooperation in the sphere of the development of aircraft and navigational equipment for civilian aircraft. A preliminary agreement was attained on the sale of S-300PMU, S-300V, and Tor SAM Systems abroad.

On the opening day of the air show, the signing of an agreement took place between Russian International Airlines—Aeroflot, the Aviation Complex imeni S.V. Ilyushin, and the Voronezh Aircraft Production Association on the delivery of 20 Il-96M aircraft equipped with

American Pratt & Whitney engines and Rockwell-Collins equipment to Aeroflot beginning in 1995 (the aircraft's first flight is planned for March 1993 and they propose deliveries beginning in 1995). At the same time, the receipt of an order for three Il-96M aircraft from Uzbek National Airlines was announced. The next day the signing of an agreement between Aeroflot, Rockwell-Collins, and the firm imeni S.V. Ilyushin took place for the installation of TCASII collision warning systems on Il-86 aircraft that are already being operated.

The leading Western firm Honeywell formed a new Russian firm under the name Honeywell Aviation Control Moscow to equip passenger aircraft with the latest flight-navigation equipment systems and delivered the first shipment for the new Tu-204 airliner. The former socialist countries and China displayed interest in the exhibition and restoration of cooperation with these countries is considered possible.

The American concern Allied Signal, which sent the most representative delegation among Western firms to "Mosaeroshow-92" (30 experts), is already carrying out a number of joint programs with Russian partners and Bendix, which is part of the concern, and signed an agreement at the exhibition with the NII of Aviation Equipment on joint development and production of avionics equipment for existing and future Russian aircraft. This is the first major joint project of Western and Russian enterprises on avionics. At first, they propose installing liquid crystal displays (ZhKI) developed by Bendix in Il-96, Il-114, and Tu-204 passenger aircraft that are being produced for the Russian domestic market—this should be the first employment in the world of liquid crystal displays on series-produced aircraft. The liquid crystal displays on these aircraft will be used as part of flight mode optimization systems. In the future,

they plan to develop complete flight-navigation systems based on liquid crystal displays for the Yak-42M, Yak-46, and Be-200 aircraft.

Allied Signal's projects that have already been carried out jointly with Russia are associated with other directions of the concern's activities: for example, Garret, a subsidiary of the firm, has begun to realize a major joint program with Omsk Engine Building Design Bureau for the development of a new auxiliary power plant that is oriented on Russian aircraft (which have different required air consumption than Western power plants)

and includes Garret's turbine along with an Omsk MKB compressor and other auxiliary components. Allied Signal's large-scale presence is associated with the concern's basic policy toward expansion of cooperation with the CIS as a result of the strength of the CIS aircraft industry and the promise of its domestic market.

*FLIGHT INTERNATIONAL*, 19-25 Aug 1992, V. 142, No. 4332, p. 4, 5, 7.

*FLIGHT INTERNATIONAL*, 26 Aug-01 Sep 1992, V. 142, No. 4333, p. 21.

"Mosaeroshow-92" materials.

**END OF**

**FICHE**

**DATE FILMED**

19 APR 1994